USDA United States Department of Agriculture | Forest Service | Plumas National Forest

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File Code: 2540
Date: January 24, 2006

Steve Rosenbaum
California Regional Water Quality Control Board -
Central Valley Region
3443 Routier Road, Suite A
Sacramento, CA 95827-3003

Dear Mr. Rosenbaum:

Enclosed please find the results of the third installment of the in-stream biotoxicity assessment monitoring performed by the U.S. Department of Agriculture, Forest Service, Plumas National Forest, at the Walker Mine Tailings in Plumas County.

This report is for samples collected September 9-14, 2004. Macroinvertebrate samples were analyzed by the National Aquatic Monitoring Center at Utah State University. Periphyton samples were analyzed by Hannaea laboratory in Helena, Montana. Future reports for the biological sampling events, including the sampling performed in 2005 and the sampling to be performed in 2006, will be delivered to your office by June 15 of the calendar year following the sampling event.

The 2001 Amended Record of Decision for the Walker Mine Tailings site provides for the diversion of Dolly Creek around the tailings material. The design for this diversion channel was completed by a consulting engineering firm in September 2005. The construction contract for the diversion channel will be advertised by the Plumas National Forest in spring 2006. Construction is expected to begin by July 2006. Negotiations with the Atlantic Richfield Company (ARCO), a Potentially Responsible Party for the site, were completed in 2005, with the Forest Service receiving a settlement that will cover a large portion of the anticipated site remediation costs.

Please call Joe Hoffman of this office at (530) 283-7868 if you have questions.

Sincerely,

James M Peña

JAMES M. PEÑA
Forest Supervisor

cc: Dennis J Geiser

BIOLOGICAL MONITORING REPORT

Discharger: USDA Forest Service, Plumas National Forest

Facility: Walker Mine Tailings, Plumas County

Reporting Frequency: Annual

Monitoring Period: 2004

Findings:

Macroinvertebrate and periphyton samples from Little Grizzly Creek and Indian Creek were collected for this year's report during late September and early October of 2004. Samples were collected at the same 8 sites for the 2002 and 2003 reports. Sample collection was performed per the U.S. Forest Service's (USFS's) Pacific Southwest Region Stream Bioassessment Protocols and was consistent with the in-stream biotoxicity assessment program for Walker Mine Tailings that was reviewed by the CA Regional Water Quality Control Board in March 2002.

The macroinvertebrate and periphyton sample analyses both indicate significant aquatic health impairment at site 2, the first site on Little Grizzly Creek that is situated below the confluence of Little Grizzly Creek and the stream that flows over the mine tailings, Dolly Creek (site 2 is located at Brown's Cabin, which is the compliance station for chemical and physical water quality). The analyses for both components (macroinvertebrate and periphyton) demonstrated essentially full recovery from the tailings pollution at site 6, the lowest sample site on Little Grizzly Creek, situated approximately 8 miles downstream of the confluence with Dolly Creek (see the attached map). Sample results demonstrated no significant impact between sites 7 and 8 on Indian Creek, indicating that the mine tailings pollution in Little Grizzly Creek is not affecting Indian Creek.

The background sample location is site 1, located on Little Grizzly Creek above its confluence with Dolly Creek. While numerous indications of impairment were observed in the macroinvertebrate data for this site in 2002 and 2003, the 2004 data indicates very good water quality, particularly in relation to the other 7 sites. Of the 8 sites surveyed, site 1 ranked first in abundance, Shannon diversity and total taxa richness and second in Hilsenhoff Biotic Index (see Table 1 and Chart 1). However, the family Chironomidae (midge), a group of macroinvertebrates that are decidedly tolerant of poor water quality, remains the dominant family at site 1; percent abundance for this site-dominant species increased from 18% in 2003 to 25% in 2004.

The periphyton results for site 1 also indicate unimpaired water quality. The dominant species at site 1 was *Cocconeis placentula*, a species that is sensitive to both metals and organic pollution. The sole, minor impairment indicated by the site 1 periphyton data is the siltation index, which ranked fifth of the 8 sites surveyed (see Table 2 and Chart 2).

Site 1 is situated just downstream of a 2-mile long meadow reach of Little Grizzly Creek. This is the only reach of Little Grizzly Creek that is subjected to cattle grazing. Trampled and eroding banks, as well as organic input from cattle feces, are possible causes for the minor water quality impairments indicated at site 1. The grazing allotment reach of Little Grizzly Creek was fenced off from cattle and an alternate water source provided for the cattle beginning in 2004 to reduce these possible causes of impairment. The improvement in water quality at site 1 indicated by the 2004 data (as compared with the 2002 and 2003 data) may well be the result of these stream protections at the grazing allotment.

In summary, site 1 demonstrates very good, relatively unimpaired water quality and serves well as a control site for the study of biological impacts from Walker Mine Tailings on Little Grizzly and Indian Creeks.

Two caveats must be stated regarding the above periphyton discussion. These caveats apply to the periphyton analysis at all 8 sites. First, the results on Table 2 are highlighted for values that indicate minor, moderate or severe impairment. The biocriteria that determine in which category the values fall were developed on streams sampled during summer months in the Rocky Mountain ecoregions of western Montana. Because the samples for these Walker Tailings studies were collected in the Sierras and sometimes outside the summer field season, the minor, moderate or severe impairments indicated by the biocriteria may not be appropriate for evaluating these data. Of course, it is completely appropriate to assess the relative impairments indicated by the periphyton results among the 8 sites. Second, the siltation index mentioned above is simply a measurement of the relative presence of highly motile periphyton species. These motile species are assumed to be present at siltated sites because non-motile species cannot thrive on streambeds where significant sedimentation occurs. However, many species in the motile genera *Navicula*, *Nitzschia*, and *Surirella* also tend to be tolerant of other forms of pollution, including excess nutrients and heavy metals. Therefore, a high siltation index may be the result of other forms of pollution besides sedimentation.

As in prior years, the 2004 macroinvertebrate and periphyton sample analyses both indicate significant aquatic health impairment at site 2.

The macroinvertebrate results rank site 2 as the poorest of the 8 sites surveyed for most parameters, including abundance of EPT organisms, Shannon diversity, and Hilsenhoff Biotic Index (HBI). At site 2, Chironomidae represented the dominant family, making up 80% (up from 56% in 2002 and 78% in 2003) of the organisms observed, the largest dominant species percentage of the 8 sites.

Periphyton data for site 2 indicates low diatom species richness and diversity and elevated numbers of highly motile, pollution tolerant, and morphologically defective diatoms. Site 2 is dominated by two periphyton diatom species, *Achnanthidium* *minutissimum* (a species known to be tolerant of acid mine drainage and the associated elevated concentrations of heavy metals) at 36.48% and *Nitzschia palea* (a species that is an obligate nitrogen heterotroph and requires large concentrations of organic nitrogen for optimum growth and population development) at 25.15%. The dominant species at site 1, the sensitive *Cocconeis placentula* species, almost disappeared at site 2.

Both biological monitoring components indicate recovery for the aquatic health of Little Grizzly Creek as it flows downstream from its confluence with Dolly Creek. This recovery is virtually total and complete at site 6.

Macroinvertebrate richness, diversity and HBI demonstrate a trend that generally improves steadily from sites 3 to 6 and, for the 8 sites surveyed, rank highest or second only to site 1 at site 6. Little Grizzly Creek between sites 2 and 6 is a stable, canyon reach fed by numerous high quality tributary streams situated in watersheds of low road density. Furthermore, since site 6 is situated well downstream of the above mentioned impairments due to cattle grazing and mine tailings pollution, it is expected that the site would demonstrate numerous water quality indicators that are the highest of the 8 sites surveyed.

The attached bar graph, "Chart 3: Invertebrate Abundance by Functional Feeding Group, 2004", indicates both the increase in numbers of invertebrates in most functional feeding groups and the relative shift in the mix of functional feeding groups from site 2 to site 6 (with the exception of site 4 where the collector-gatherers spike even higher than site 2). The very high percentage of collector-gatherers at site 2 feed on deposited fine particulate organic matter. This suggests a low percentage of the other food sources, such as animal tissue, vascular plants or periphyton. At each successive site, additional functional feeding groups are added, indicating that the food sources are closer to being balanced. Finally, by site 6, equilibrium of functional feeding groups similar to site 1 has been reached.

The periphyton data also indicates recovery in water quality from the impaired site 2 to site 6, although this recovery is not as pronounced as the macroinvertebrate data indicates and site 6 does not rank the highest for any of the periphyton metrics measured at the 8 sites. Compared with site 2, the pollution, siltation and disturbance indices, as well as the Shannon Diversity, are all significantly improved at site 6 to the point that these indices are again close to the background values measured at site 1. Interestingly, the percent abnormal cells observed at site 6 (1.08%) exceeds that observed at site 2 (0.35%).

Overall, the periphyton data for sites 1 and 6 indicate relatively unimpaired water quality and full support for aquatic life uses. However, similar to the 2003 results, the 2004 periphyton data for sites 2 through 5 indicate significant impairment for at least four metrics. These sites all generally demonstrated low diatom richness and diversity and elevated counts of motile, pollution tolerant and morphologically defective cells. The most significant recovery of the periphyton community is observed between sites 5 and 6.

Similarly, the steady recovery in water quality as indicated by the macroinvertebrate data gathered in Little Grizzly Creek as it flows downstream from Dolly Creek is derailed at site 4 and, to a lesser extent, at site 5. While the macroinvertebrate richness, diversity and Hilsenhoff Biotic Index all improve between sites 2 and 3, these indices all decline or remain virtually unchanged at site 4 before improving again at site 5. The abundance of macroinvertebrates decreases steadily from site 3 to site 5 with the dominant species family, Chironomidae, representing large percentages of the community. The macroinvertebrate indices all improve dramatically between sites 5 and 6, where all macroinvertebrate characterizations indicate the highest water quality of any of the sites downstream from site 1.

Poor water quality at sites 3 and 4 was evident in the 2003 data but not evident in the 2002 data. Specifically, the 2002 macroinvertebrate data showed a steady recovery from site 2 to site 6 with gradual and significant improvement in richness, diversity and HBI at each subsequent monitoring site. A steady recovery is expected from sites 2 to 6 because this reach of Little Grizzly Creek is stable and controlled by bedrock and large cobbles and boulders. Also, there are no identified sources of heavy metal pollution below site 2, no significant cattle grazing, and few roads in the small watersheds that feed this reach of Little Grizzly Creek.

More investigation is necessary to determine the likely cause of impairment indicated in 2003 at sites 3 and 4 and in 2004 at sites 3, 4 and 5. Possible causes include the small-scale dredge mining that has occurred throughout the past decade within and immediately adjacent to these two sites as well as the larger-scale placer mining that occurred historically on the tributary streams that feed this reach of Little Grizzly Creek from the southwest. While the likely obvious cause for impairment at site 2 is the input of heavy metals and sediment from the Walker Mine tailings site, the periphyton data indicate that probable causes of impairment at sites 3 through 5 are mine drainage (possibly acidic) with associated heavy metals, organic (mostly nitrogen) enrichment, and excessive sedimentation.

The macroinvertebrate and periphyton data indicated good biological integrity on Indian Creek at both sample sites (7 and 8), suggesting good water quality that supports full aquatic life uses. In fact, the periphyton diatom associations above and below Indian Creek's confluence with Little Grizzly Creek were virtually identical in all three years of sampling. Macroinvertebrate results were also remarkably similar, particularly in 2004. Since the biological monitoring parameters for Little Grizzly Creek at site 6, just upstream of its confluence with Indian Creek, indicate good water quality, it is logical that there would be little or no measurable effect in Indian Creek water quality due to the in-flow of Little Grizzly Creek.

As we indicated in our 2002 and 2003 reports, serious consideration should be given to eliminating sites 7 and 8 from future studies as it is unlikely that such monitoring will demonstrate any measurable impacts on Indian Creek due to pollution from the Walker Mine Tailings site.

ATTACHMENTS

- Descriptions and Maps of the biological sampling locations
- Table 1: Macroinvertebrate Results Summary
- Chart 1: Macroinvertebrate Results, 2004
- Table 2: Periphyton Results Summary
- Chart 2: Periphyton Diatom Metrics, 2004
- Chart 3: Invertebrate Abundance by Functional Feeding Group, 2004
- "Aquatic Invertebrate Report for samples collected within Plumas National Forest, California, September 2004", Utah State University, February 2005
- "Effect of the Walker Mine Tailings on Periphyton in Little Grizzly Creek and Indian Creek, Plumas National Forest, California, 2002-2004", Dr. Loren Bahls, Helena, Montana, March 2005

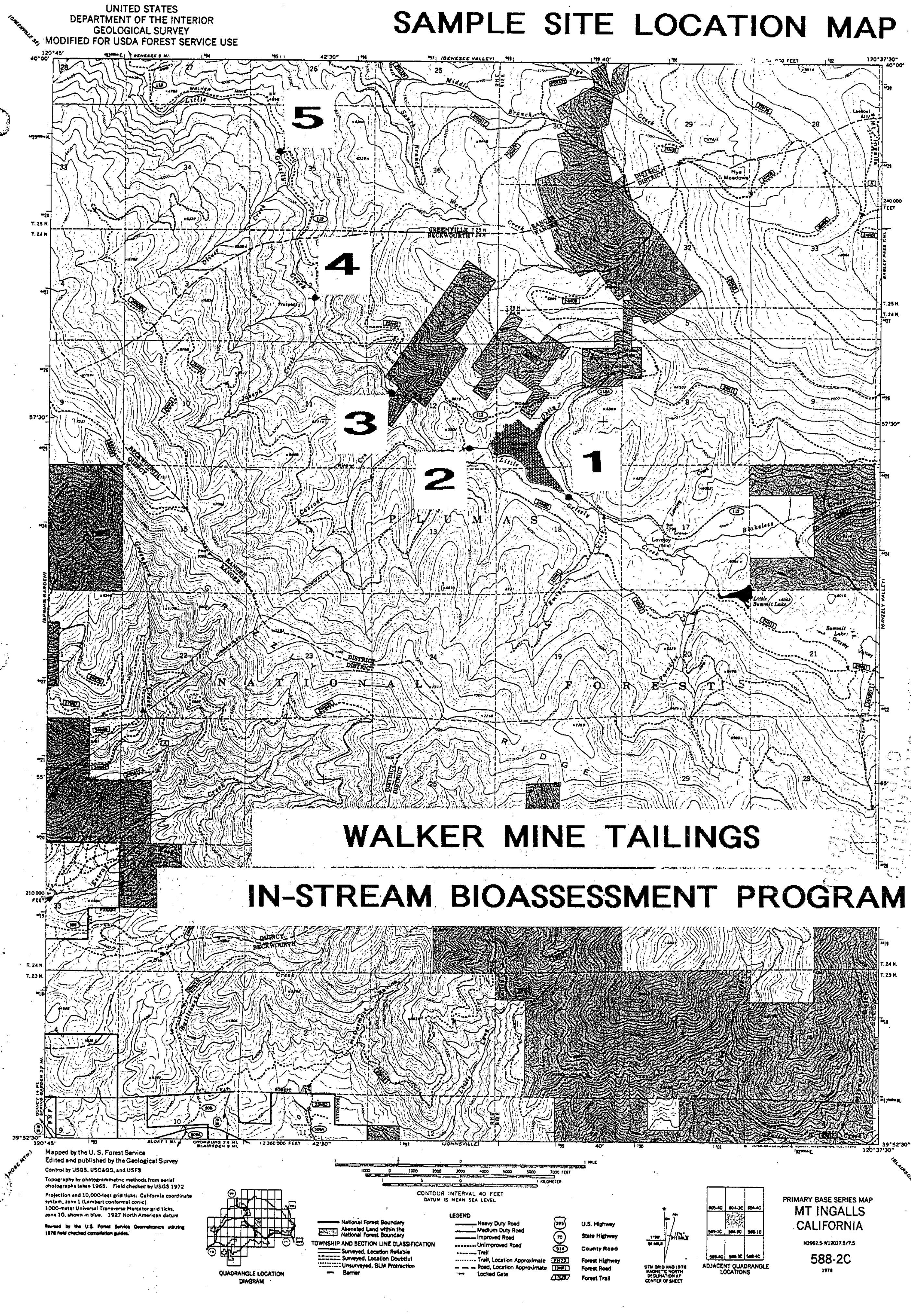
Location Descriptions: Walker Mine Tailings Biological Sampling Sites

On Little Grizzly Creek:

1. At surface water monitoring site R-3, Little Grizzly Creek upstream of the tailings area. The site will be used as a control.
2. At surface water monitoring site R-5, Little Grizzly Creek downstream of its confluence with Dolly Creek and the tailings area and upstream of the Brown's Cabin spring. R-5 is the surface water compliance site.
3. Immediately downstream from Cascade Creek.
4. Approximately 1100 feet downstream from Joseph Creek and immediately downstream from an unnamed stream.
5. Approximately 1700 feet downstream from Oliver Creek.
6. At the USGS gage site (no longer operated), approximately one mile upstream from Genesee Valley.

On Indian Creek:

7. Upstream of Little Grizzly Creek near County Road 112 bridge. The site will be used as a control site.
8. Approximately 2000 feet downstream from Little Grizzly Creek.


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
MODIFIED FOR USDA FOREST SERVICE USE
SAMPLE SITE LOCATION MAP
5
4
3
2
1
PLUMAS
NATIONAL FOREST
WALKER MINE TAILINGS
IN-STREAM BIOASSESSMENT PROGRAM
Mapped by the U. S. Forest Service
Edited and published by the Geological Survey
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL
QUADRANGLE LOCATION DIAGRAM
ADJACENT QUADRANGLE LOCATIONS
PRIMARY BASE SERIES MAP
MT INGALLS
CALIFORNIA
588-2C

SAMPLE SITE LOCATION MAP

WALKER MINE TAILINGS

IN-STREAM BIOASSESSMENT PROGRAM

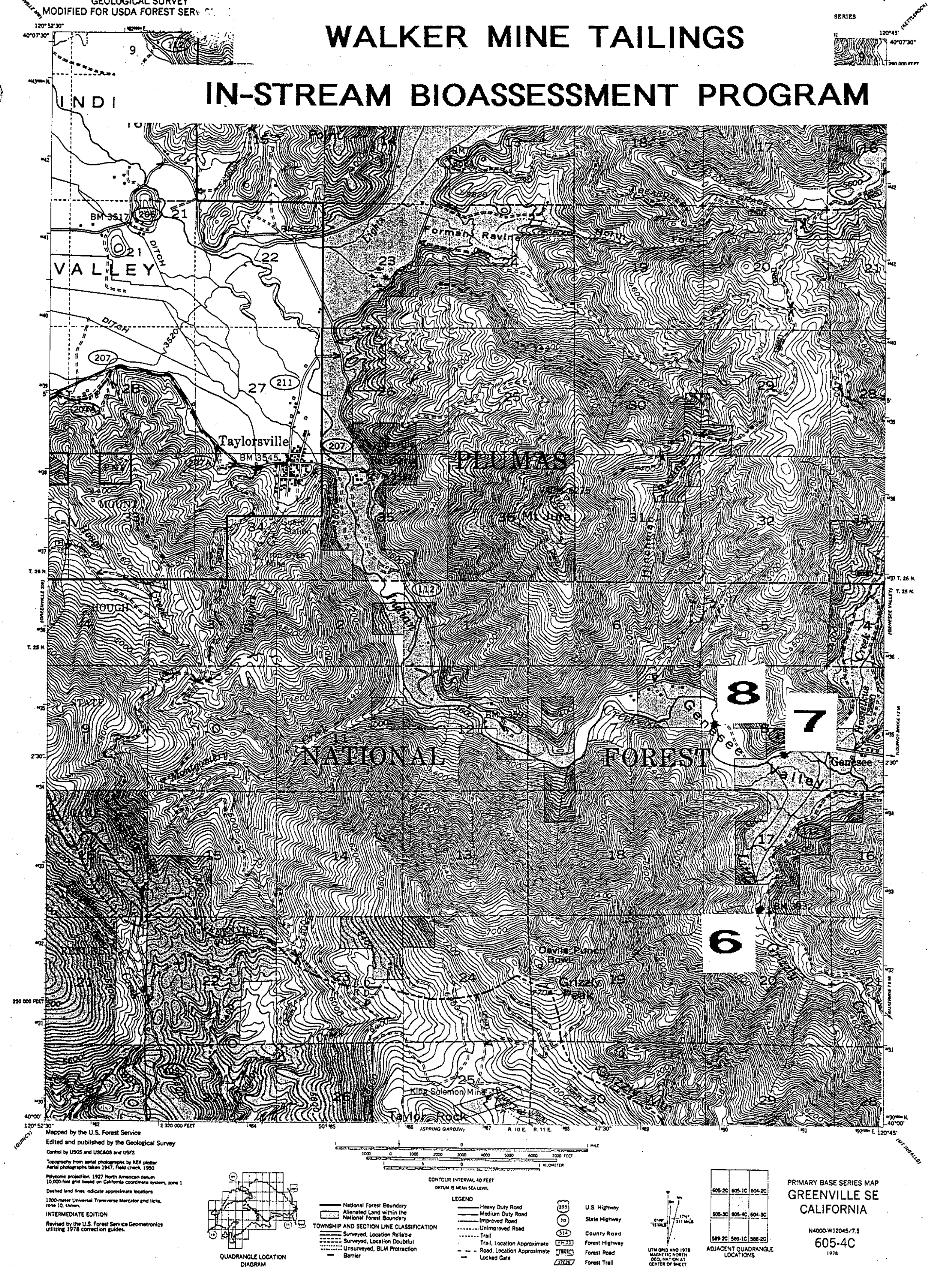


TABLE 1: MACROINVERTEBRATE RESULTS SUMMARY

IN-STREAM BIOTOXICITY ASSESSMENT PROGRAM
U.S. DEPARTMENT OF AGRICULTURE, PLUMAS NATIONAL FOREST
WALKER MINE TAILINGS, PLUMAS COUNTY
SEPTEMBER – OCTOBER 2004

Sample Station	Total Abundance (rank)	EPT* Abundance (rank)	Dominant Family (% contributed)	Total Taxa Richness (rank)	Shannon Diversity (rank)	Hilsenhoff Biotic Index (rank)	Ranking Totals (relative impairment)
1	10312 (1)	4091 (3)	Chironimidae (25%)	51 (1)	2.94 (1)	3.47 (2)	(8)
2	6968 (5)	718 (8)	Chironimidae (80%)	23 (6)	1.145 (8)	5.41 (8)	(35)
3	9091 (3)	5325 (1)	Hydroptilidae (48%)	35 (4)	1.784 (6)	4.43 (6)	(20)
4	8646 (4)	2837 (6)	Chironimidae (63%)	38 (3)	1.736 (7)	4.86 (7)	(27)
5	5681 (7)	2600 (7)	Chironimidae (40%)	51 (1)	2.721 (3)	3.89 (5)	(23)
6	9352 (2)	4558 (2)	Chironimidae (27%)	44 (2)	2.753 (2)	3.19 (1)	(9)
7	4466 (8)	3366 (5)	Hydropsychidae (55%)	33 (5)	2.464 (4)	3.69 (3)	(25)
8	5870 (6)	3639 (4)	Hydropsychidae (38%)	33 (5)	2.447 (5)	3.85 (4)	(24)

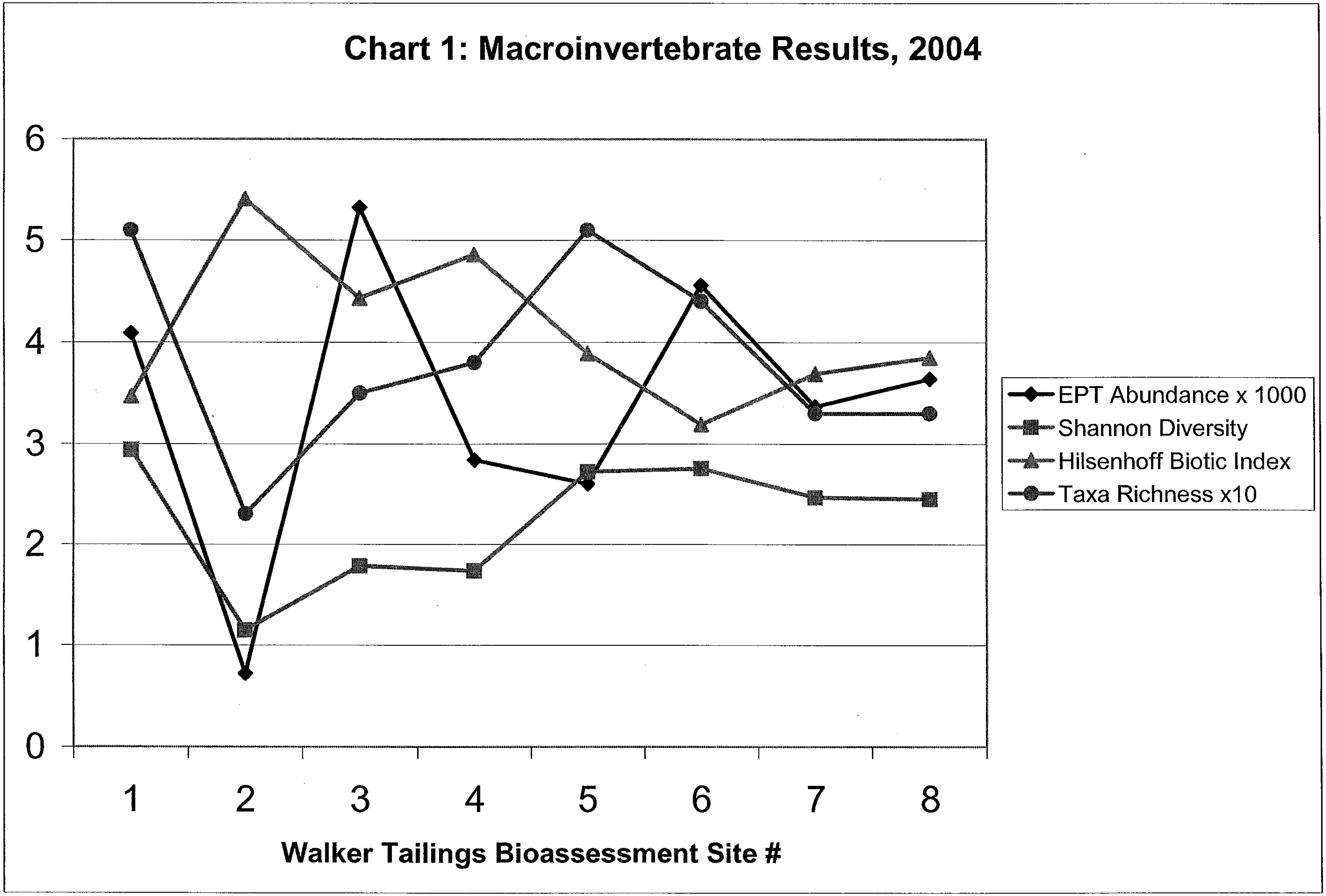


Chart 1: Macroinvertebrate Results, 2004
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
Walker Tailings Bioassessment Site #
EPT Abundance x 1000
Shannon Diversity
Hilsenhoff Biotic Index
Taxa Richness x10

TABLE 2: PERIPHYTON RESULTS SUMMARY

IN-STREAM BIOTOXICITY ASSESSMENT PROGRAM
U.S. DEPARTMENT OF AGRICULTURE, PLUMAS NATIONAL FOREST
WALKER MINE TAILINGS, PLUMAS COUNTY
SEPTEMBER – OCTOBER 2004

Sample Station	Number of Species counted (rank)	Percent Abnormal Cells (rank)	Dominant Species (% contributed) (rank)	Siltation Index (rank)	Disturbance Index (rank)	Shannon Diversity (rank)	Pollution Index (rank)	Ranking Totals (relative impairment)
1	56 (2)	0.00 (1)	*Cocconeis placentula* (19.2%) (3)	37.05 (5)	6.80 (3)	4.44 (2)	2.57 (5)	(21)
2	33 (5)	0.35 (5)	*Achnanthidium minutissimum* (36.5%) (5)	39.79 (6)	36.48 (7)	3.08 (6)	2.17 (7)	(41)
3	29 (6)	2.66 (8)	*Nitzschia dissipata* (17.1%) (1)	**55.38** (7)	13.91 (4)	3.69 (3)	2.14 (8)	(37)
4	20 (8)	0.45 (6)	*Nitzschia dissipata* (38.3%) (6)	**73.36** (8)	15.01 (5)	2.68 (7)	2.49 (6)	(46)
5	22 (7)	0.34 (4)	*Achnanthidium minutissimum* (**57.7%**) (8)	25.34 (3)	**57.65** (8)	2.19 (8)	2.70 (2)	(40)
6	34 (4)	1.08 (7)	*Gomphonema kobayasii* (19.1%) (2)	26.89 (4)	15.97 (6)	3.66 (4)	2.66 (4)	(31)
7	54 (3)	0.11 (3)	*Staurosira construens* (43.2%) (7)	12.85 (1)	1.00 (2)	3.63 (5)	2.77 (1)	(22)
8	63 (1)	0.10 (2)	*Staurosira construens* (24.7%) (4)	22.38 (2)	0.73 (1)	4.46 (1)	2.70 (2)	(13)

Underlined values: minor impairment; **bold values:** moderate impairment; **underlined and bold**: severe impairment

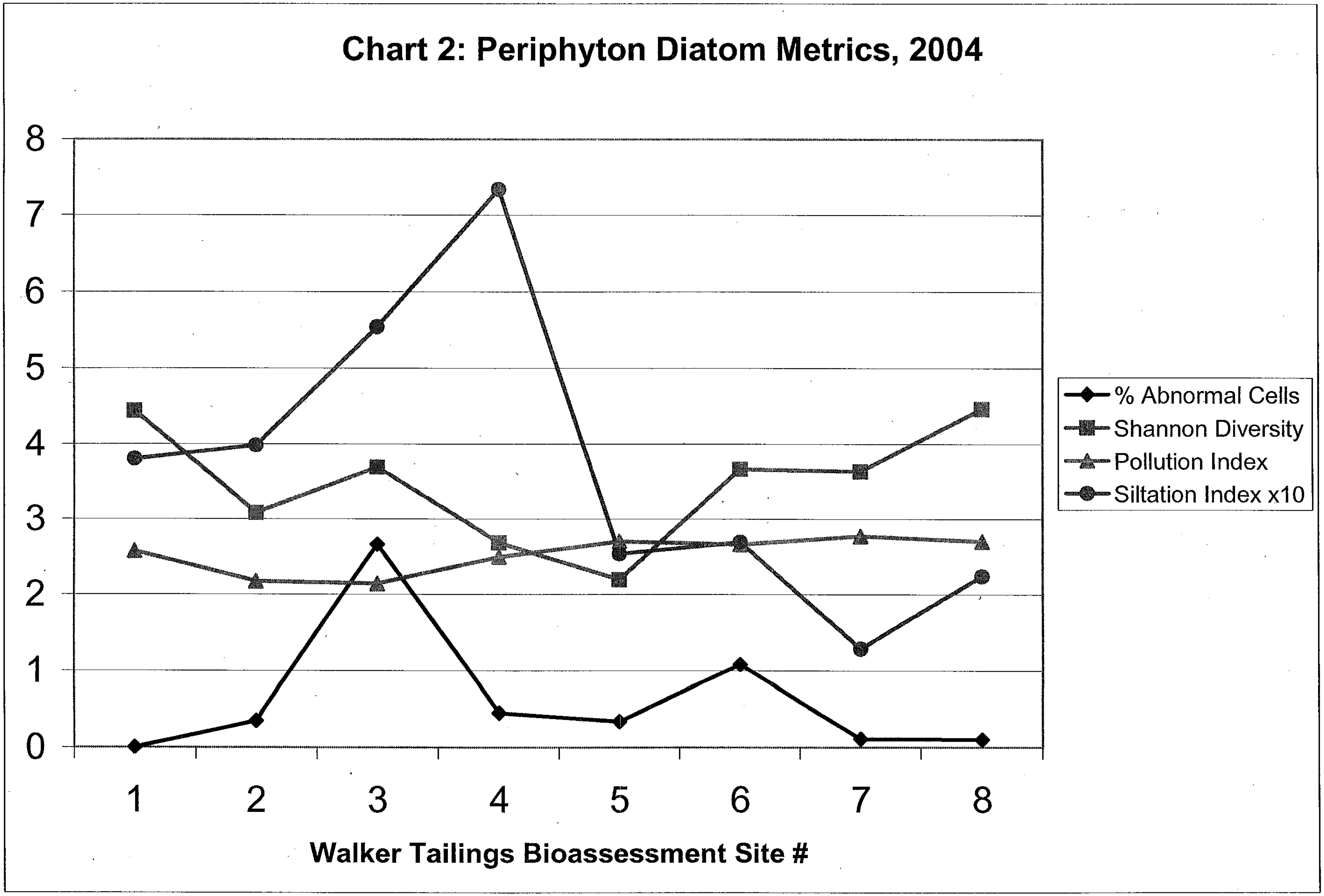


Chart 2: Periphyton Diatom Metrics, 2004
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
Walker Tailings Bioassessment Site #
% Abnormal Cells
Shannon Diversity
Pollution Index
Siltation Index x10

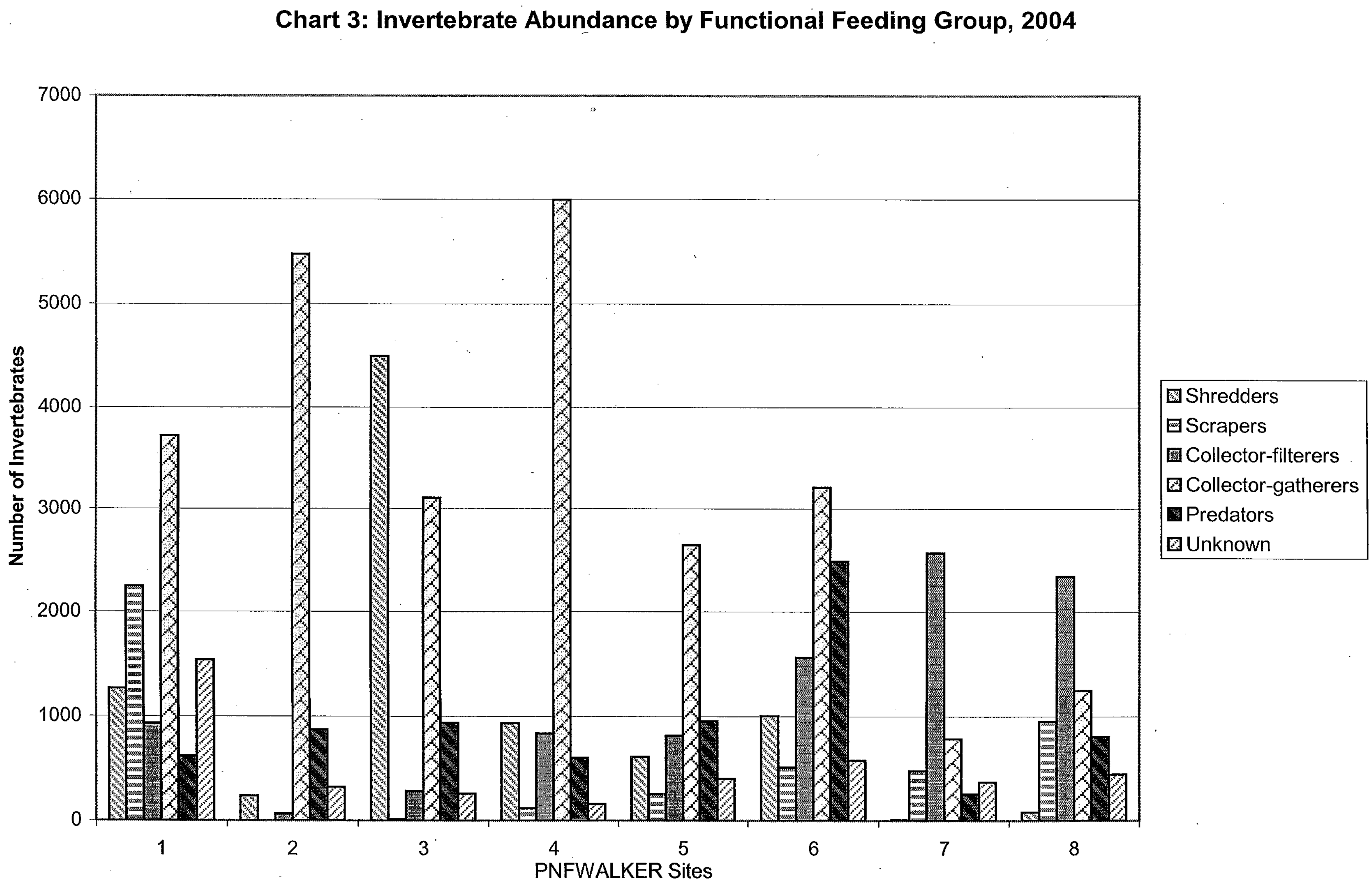


Chart 3: Invertebrate Abundance by Functional Feeding Group, 2004
Number of Invertebrates
7000
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
PNFWALKER Sites
Shredders
Scrapers
Collector-filterers
Collector-gatherers
Predators
Unknown

BIOASSESSMENT 2004

AQUATIC MACROINVERTEBRATE ANALYSES REPORT

Aquatic Invertebrate Report for samples collected within the Plumas National Forest, California September 2004

Report prepared for:
United States Forest Service
Plumas National Forest
Post Office Box 11500
159 Lawrence Street
Quincy, California 95971-6025

Report prepared by:
Mark Vinson
U.S.D.I. Bureau of Land Management
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435.797.2038

25 February 2005

Sampling Locations
All samples were collected within Plumas County, California (Table 1).

Table 1. List of sampling locations.

Station ID	Location	Latitude Degrees North	Longitude Degrees West	Elevation (meters)
PNFWALKER1	Little Grizzly Creek, Site 1	39.948	120.669	1768
PNFWALKER2	Little Grizzly Creek, Site 2	39.955	120.686	1737
PNFWALKER3	Little Grizzly Creek, Site 3	39.96	120.697	1646
PNFWALKER4	Little Grizzly Creek, Site 4	39.971	120.711	1536
PNFWALKER5	Little Grizzly Creek, Site 5	39.993	120.718	1439
PNFWALKER6	Little Grizzly Creek, Site 6	40.016	120.753	1295
PNFWALKER7	Indian Creek, Site 1	40.042	120.76	1123
PNFWALKER8	Indian Creek, Site 2	40.044	120.775	1119

Methods

Aquatic invertebrate sampling

Aquatic invertebrates were collected from riffle habitats using a kick net with a 500 micron mesh net. Samples were collected between 9 and 24 September 2004. Samples were collected over an approximately one square meter area from riffle habitats.

Laboratory methods

The general procedures followed for processing invertebrate samples were similar to those recommended by the United States Geological Survey (Cuffney et al. 1993) and are described in greater detail and rationalized in Vinson and Hawkins (1996). Methods for individual samples are presented in Table 3. Samples were sub-sampled if the sample appeared to contain more than 600 organisms. Sub-samples were obtained by pouring the sample into an appropriate diameter 250 micron sieve, floating this material by placing the sieve within an enamel pan partially filled with water and leveling the material within the sieve. The sieve was then removed from the water pan and the material within the sieve was divided into equal parts. One side of the sieve was then randomly chosen to be processed and the other side was set aside. The sieve was then placed back in the enamel pan and the material in the sieve again leveled and split in half. This process was repeated until approximately 600 organisms remained in one-half of the sieve. This material was then placed into a petri dish and all organisms were removed under a dissecting microscope at 10-30 power. Additional sub-samples were taken until at least 600 organisms were removed. All organisms within a sub-sample were removed. During the sorting process the organisms were separated into Orders. When the sorting of the sub-samples was completed, the entire sample was spread throughout a large white enamel pan and searched for 10 minutes to remove any taxa that might not have been picked up during the initial sample sorting process. The objective of this "big/rare" search was to provide a more complete taxa list by finding rarer taxa that may have been excluded during the sub-sampling process. These rarer bugs were placed into a separate vial and tracked separately from the bugs removed during the sub-sampling process. All the organisms removed during the sorting process were then identified. Once the data had been entered into a computer and checked, the unsorted portion of the sample was discarded. The identified portion of the sample was placed in 70% ethanol, given a catalog number, and was retained.

Table 2. Laboratory sample processing information. The percentage of each sample processed and the total number of invertebrates identified for each sample are reported.

Sample ID	Station ID	Sampling date	% of sample processed	Invertebrates identified
123901	PNFWALKER1	9/9/2004	6	667
123902	PNFWALKER2	9/9/2004	9	679
123903	PNFWALKER3	9/10/2004	8	757
123904	PNFWALKER4	9/10/2004	8	725
123905	PNFWALKER5	9/13/2004	13	767
123906	PNFWALKER6	9/13/2004	7	768
123907	PNFWALKER7	9/14/2004	16	817
123908	PNFWALKER8	9/14/2004	13	802

Data summarization

A number of metrics or ecological summaries were provided for each sampling station. These metrics were calculated as follows:

Taxa richness - Richness is a component and estimate of community structure and stream health based on the number of distinct taxa. Taxa richness normally decreases with decreasing water quality. In some situations organic enrichment can cause an increase in the number of pollution tolerant taxa. Taxa richness was calculated for operational taxonomic units (OTUs) and the number of unique genera or families. The values for operational taxonomic units may be overestimates of the true taxa richness at a site if individuals were the same taxon as those identified to lower taxonomic levels or they may be underestimates of the true taxa richness if multiple taxa were present within a larger taxonomic grouping but were not identified. All individuals within all samples were generally identified similarly, so that comparisons in operational taxonomic richness among samples within this dataset are appropriate, but comparisons to other data sets may not. Comparisons to other datasets should be made at the genera or family level.

Abundance - The abundance, density, or number of aquatic macroinvertebrates per unit area is an indicator of habitat availability and fish food abundance. Abundance may be reduced or increased depending on the type of impact or pollutant. Increased organic enrichment typically causes large increases in abundance of pollution tolerant taxa. High flows, increases in fine sediment, or the presence of toxic substances normally cause a decrease in invertebrate abundance. Invertebrate abundance is presented as the number of individuals per square meter for quantitative samples and the number of individuals collected for qualitative samples.

EPT - A summary of the taxa richness and abundance among the insect Orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). These orders are commonly considered sensitive to pollution.

Number of families - All families are separated and counted. The number of families normally decreases with decreasing water quality.

Percent taxon or family dominance – An assemblage dominated by a single taxon or several taxa from the same family suggests environmental stress.

Shannon Diversity Index - Ecological diversity is a measure of community structure defined by the relationship between the number of distinct taxa and their relative abundances. The Shannon diversity index was calculated for each sampling location for which there were a sufficient number of individuals and taxa collected to perform the calculations. The calculations were made following Ludwig and Reynolds (1988, equation 8.9, page 92).

Evenness - Evenness is a measure of the distribution of taxa within a community. The evenness index used in this report was calculated following Ludwig and Reynolds (1988, equation 8.15, page 94). Value ranges from 0-1 and approach zero as a single taxa becomes more dominant.

Biotic indices - Biotic indices use the indicator taxa concept. Taxa are assigned water quality tolerance values based on their specific tolerances to pollution. Scores are typically weighted by taxa relative abundance. In the United States the most commonly used biotic index is the Hilsenhoff Biotic Index (Hilsenhoff 1987, Hilsenhoff 1988). The Hilsenhoff Biotic Index (HBI) summarizes the overall pollution tolerances of the taxa collected. This index has been used to detect nutrient enrichment, high sediment loads, low dissolved oxygen, and thermal impacts. It is best at detecting organic pollution. Families were assigned an index value from 0- taxa normally found only in high quality unpolluted water, to 10- taxa found only in severely polluted waters. Family level values were taken from Hilsenhoff (1987, 1988) and a family level HBI was calculated for each sampling location for which there were a sufficient number of individuals and taxa collected to perform the calculations. Sampling locations with HBI values of 0-2 are considered clean, 2-4 slightly enriched, 4-7 enriched, and 7-10 polluted. Rather than using mean HBI values for a sample, taxon HBI values can also be used to determine the number of pollution intolerant and tolerant taxa occurring at a site. In this report taxa with HBI values of 0-2 were considered intolerant clean water taxa and taxa with HBI values of 9-10 were considered pollution tolerant taxa. The number of tolerant and intolerant taxa and the abundances of tolerant and intolerant taxa were calculated for each sampling location.

USFS Community tolerant quotient - This index has been widely used by the USFS and BLM throughout the western United States. Taxa are assigned a tolerant quotient (TQ) from 2-taxa found only in high quality unpolluted water, to 108 - taxa found in severely polluted waters. TQ values were developed by Winget and Mangum (1979). The dominance weighted community tolerance quotient (CTQd) was calculated. Values can vary from about 20 to 100, in general the lower the value the better the water quality.

Functional feeding group measures – A common classification scheme for aquatic macroinvertebrates is to categorize them by feeding acquisition mechanisms. Categories are based on food particle size and food location, e.g., suspended in the water column, deposited in sediments, leaf litter, or live prey. This classification system reflects the major source of the resource, either within the stream itself or from riparian or upland areas and the primary location, either erosional or depositional habitats. The number of taxa and individuals of the following feeding groups were calculated for each sampling location.

Shredders - Shredders use both living vascular hydrophytes and decomposing vascular plant tissue - coarse particulate organic matter (CPOM). Shredders are sensitive to changes in riparian vegetation. Shredders can be good indicators of toxicants that adhere to organic matter.

Scrapers - Scrapers feed on periphyton - attached algae and associated material. Scraper populations increase with increasing abundance of diatoms and can decrease as filamentous algae, mosses, and vascular plants increase. Scrapers decrease in relative abundance in response to sedimentation and organic pollution.

Collector-filterers - Collector-filterers feed on suspended fine particulate organic matter (FPOM). Collector-gatherers are sensitive to toxicants in the water column and deposited in sediments.

Collector-gatherers - Collector-gatherers feed on deposited fine particulate organic matter. Collector-gatherers are sensitive to deposited toxicants.

Predators - Predators feed on living animal tissue.

Unknown feeding group - This category includes taxa that are highly variable, parasites, and those that for which the primary feeding mode is currently unknown.

Clinger taxa - The number of clinger taxa have been found by Karr and Chu (1998) to respond negatively to human disturbance. Clinger taxa were determined using information in Merritt and Cummins (1996). These taxa typically cling to the tops of rocks and are thought to be reduced by sedimentation or abundant algal growths

Long-live taxa – The number of long-lived taxa was calculated the number of taxa collected that typically have 2-3 year life cycles. Disturbances and water quality and habitat impairment typically reduces the number of long-lived taxa Karr and Chu (1998). Life-cycle length determinations were based on information in Merritt and Cummins (1996) and Dr. Mark Vinson's knowledge of the invertebrate fauna of Utah.

Results

Abundance data are reported as the estimated number of individuals per square meter for quantitative samples and the estimated number of individuals collected for qualitative samples. Taxa richness data are the number per sample. NC = Not calculated. * = unable to calculate. EPT = totals for the insect orders, Ephemeroptera, Plecoptera, Trichoptera.

Station ID	Sampling date	Sample ID	Total abundance	EPT abundance	# of families	Dominant family	Dominant family abundance	Dominant family % contribution
PNFWALKER1	9/9/2004	123901	10312	4091	29	Chironomidae	2592	25.14
PNFWALKER2	9/9/2004	123902	6968	718	12	Chironomidae	5543	79.55
PNFWALKER3	9/10/2004	123903	9091	5325	18	Hydroptilidae	4353	47.88
PNFWALKER4	9/10/2004	123904	8646	2837	20	Chironomidae	5480	63.38
PNFWALKER5	9/13/2004	123905	5681	2600	24	Chironomidae	2312	40.7
PNFWALKER6	9/13/2004	123906	9352	4558	21	Chironomidae	2554	27.31
PNFWALKER7	9/14/2004	123907	4466	3366	19	Hydropsychidae	2477	55.46
PNFWALKER8	9/14/2004	123908	5870	3639	19	Hydropsychidae	2239	38.14
Mean			7548	3392	20		3444	45.62

Diversity indices

Station ID	Sampling date	Sample ID	Total taxa richness	EPT taxa richness	Shannon diversity	Simpson diversity	Evenness
PNFWALKER1	9/9/2004	123901	51	25	2.94	0.091	0.56
PNFWALKER2	9/9/2004	123902	23	8	1.145	0.605	0.305
PNFWALKER3	9/10/2004	123903	35	18	1.784	0.31	0.449
PNFWALKER4	9/10/2004	123904	38	23	1.736	0.4	0.322
PNFWALKER5	9/13/2004	123905	51	33	2.721	0.142	0.424
PNFWALKER6	9/13/2004	123906	44	28	2.753	0.095	0.65
PNFWALKER7	9/14/2004	123907	33	18	2.464	0.138	0.579
PNFWALKER8	9/14/2004	123908	33	19	2.447	0.12	0.693
Mean			38.5	21.5	2.249	0.238	0.498

Biotic Indices

Station ID	Sampling date	Sample ID	Hilsenhoff Biotic Index	Indication	CTQp	CTQa	CTQd	BCI	Indication
PNFWALKER1	9/9/2004	123901	3.47	Slight organic enrichment	66	68	69	96	Excellent
PNFWALKER2	9/9/2004	123902	5.41	Moderate organic enrichment	50	80	83	60	Poor
PNFWALKER3	9/10/2004	123903	4.43	Moderate organic enrichment	50	65	72	69	Poor
PNFWALKER4	9/10/2004	123904	4.86	Moderate organic enrichment	50	57	62	81	Good
PNFWALKER5	9/13/2004	123905	3.89	Slight organic enrichment	66	59	62	106	Excellent
PNFWALKER6	9/13/2004	123906	3.19	Slight organic enrichment	50	54	60	83	Excellent
PNFWALKER7	9/14/2004	123907	3.69	Slight organic enrichment	66	73	77	86	Excellent
PNFWALKER8	9/14/2004	123908	3.85	Slight organic enrichment	50	71	72	69	Poor
Mean			4.1		56	66	70	81	

Taxa richness and relative abundance values with respect to tolerance or intolerance to pollution were based on the Hilsenhoff Biotic Index (HBI). Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are those taxa given a HBI score of 8, 9, or 10. Data are presented as the estimated number per sample.

			Intolerant				Tolerant			
Station ID	Sampling date	Sample ID	Richness		Abundance		Richness		Abundance	
PNFWALKER1	9/9/2004	123901	17	(33.00)	2920	(28.00)	1	(2.00)	16	0.00
PNFWALKER2	9/9/2004	123902	4	(17.00)	409	(6.00)	0	0.00	0	0.00
PNFWALKER3	9/10/2004	123903	13	(37.00)	599	(7.00)	0	0.00	0	0.00
PNFWALKER4	9/10/2004	123904	20	(53.00)	1204	(14.00)	0	0.00	0	0.00
PNFWALKER5	9/13/2004	123905	26	(51.00)	1556	(27.00)	0	0.00	0	0.00
PNFWALKER6	9/13/2004	123906	21	(48.00)	2374	(25.00)	0	0.00	0	0.00
PNFWALKER7	9/14/2004	123907	10	(30.00)	589	(13.00)	3	(9.00)	19	0.00
PNFWALKER8	9/14/2004	123908	10	(30.00)	872	(15.00)	0	0.00	0	0.00
Mean			15	(37.38)	1315	(16.88)	1	(1.38)	4	0.00

Functional feeding groups

Taxa richness by functional feeding group. Data are presented as the number of taxa collected.

Station ID	Sampling date	Sample ID	Shredders		Scrapers		Collector-filterers		Collector-gatherers		Predators		Unknown	
PNFWALKER1	9/9/2004	123901	7	(14.00)	9	(18.00)	5	(10.00)	11	(22.00)	13	(25.00)	6	(12.00)
PNFWALKER2	9/9/2004	123902	3	(13.00)	0	0.00	2	(9.00)	4	(17.00)	10	(43.00)	4	(17.00)
PNFWALKER3	9/10/2004	123903	4	(11.00)	1	(3.00)	3	(9.00)	5	(14.00)	15	(43.00)	7	(20.00)
PNFWALKER4	9/10/2004	123904	4	(11.00)	4	(11.00)	3	(8.00)	5	(13.00)	16	(42.00)	6	(16.00)
PNFWALKER5	9/13/2004	123905	7	(14.00)	10	(20.00)	3	(6.00)	7	(14.00)	15	(29.00)	9	(18.00)
PNFWALKER6	9/13/2004	123906	4	(9.00)	8	(18.00)	4	(9.00)	6	(14.00)	16	(36.00)	6	(14.00)
PNFWALKER7	9/14/2004	123907	1	(3.00)	4	(12.00)	6	(18.00)	10	(30.00)	10	(30.00)	2	(6.00)
PNFWALKER8	9/14/2004	123908	3	(9.00)	5	(15.00)	5	(15.00)	8	(24.00)	9	(27.00)	3	(9.00)
Mean			4	(11.00)	5	(13.00)	4	(10.00)	7	(18.00)	13	(34.00)	5	(14.00)

Invertebrate abundance by functional feeding group. Data are presented as the estimated number of individuals per square meter for quantitative samples and the estimated number of individuals collected for qualitative samples. Numbers in parentheses are percentages of the total.

Station ID	Sampling date	Sample ID	Shredders		Scrapers		Collector-filterers		Collector-gatherers		Predators		Unknown	
PNFWALKER1	9/9/2004	123901	1264	(12.00)	2244	(22.00)	931	(9.00)	3716	(36.00)	618	(6.00)	1539	(15.00)
PNFWALKER2	9/9/2004	123902	237	(3.00)	0	0.00	64	(1.00)	5475	(79.00)	873	(13.00)	320	(5.00)
PNFWALKER3	9/10/2004	123903	4493	(49.00)	13	0.00	282	(3.00)	3107	(34.00)	938	(10.00)	258	(3.00)
PNFWALKER4	9/10/2004	123904	935	(11.00)	116	(1.00)	840	(10.00)	5994	(69.00)	602	(7.00)	159	(2.00)
PNFWALKER5	9/13/2004	123905	612	(11.00)	253	(4.00)	817	(14.00)	2644	(47.00)	955	(17.00)	400	(7.00)
PNFWALKER6	9/13/2004	123906	1005	(11.00)	511	(5.00)	1562	(17.00)	3210	(34.00)	2486	(27.00)	578	(6.00)
PNFWALKER7	9/14/2004	123907	6	0.00	479	(11.00)	2568	(58.00)	785	(18.00)	257	(6.00)	370	(8.00)
PNFWALKER8	9/14/2004	123908	80	(1.00)	955	(16.00)	2340	(40.00)	1244	(21.00)	808	(14.00)	443	(8.00)
Mean			1079	(14.00)	571	(8.00)	1176	(16.00)	3272	(43.00)	942	(12.00)	508	(7.00)

The 10 metrics thought to be most responsive to human(induced disturbance (Karr and Chu 1998).

Station ID	Sampling Date	Sample ID	Total taxa richness	Ephemeroptera taxa	Plecoptera taxa	Trichoptera taxa	Long-lived taxa	Intolerant taxa	% tolerant individuals	Clinger taxa	% contribution dominant taxon	% predator
PNFWALKER1	9/9/2004	123901	51	8	10	7	13	17	0.2	24	23	6
PNFWALKER2	9/9/2004	123902	23	1	1	6	4	4	0	9	77.5	12.5
PNFWALKER3	9/10/2004	123903	35	3	8	7	6	13	0	14	47.9	10.3
PNFWALKER4	9/10/2004	123904	38	4	10	9	6	20	0	19	62.2	7
PNFWALKER5	9/13/2004	123905	51	8	11	14	8	26	0	26	33.7	16.8
PNFWALKER6	9/13/2004	123906	44	8	10	10	10	21	0	24	17	26.6
PNFWALKER7	9/14/2004	123907	33	7	5	6	8	10	0.4	16	29.4	5.8
PNFWALKER8	9/14/2004	123908	33	6	6	7	8	10	0	18	22	13.8
Mean			39	6	8	8	8	15	0.1	19	39.1	12.5

List of taxa collected in 8 samples at sites listed in Table 1. Samples were collected between 9 September 2004 and 14 September 2004. Abundance data are presented as the mean number of individuals among all samples.

Order	Family	Subfamily/Genus/species	Average abundance
Phylum: Arthropoda			
Class: Arachnida			
Trombidiformes			241.20
Class: Insecta			
Coleoptera	Dytiscidae		7.74
Coleoptera	Dytiscidae	Oreodytes	4.00
Coleoptera	Elmidae		72.00
Coleoptera	Elmidae	Ampumixis dispar	32.74
Coleoptera	Elmidae	Cleptelmis addenda	104.06
Coleoptera	Elmidae	Optioservus	275.93
Coleoptera	Elmidae	Optioservus quadrimaculatus	143.94
Coleoptera	Elmidae	Ordobrevia nubifera	2.00
Coleoptera	Elmidae	Zaitzevia	94.70
Coleoptera	Psephenidae		8.00
Coleoptera	Psephenidae	Eubrianax edwardsi	27.38
Diptera	Ceratopogonidae		46.40
Diptera	Ceratopogonidae	Probezzia	29.40
Diptera	Chironomidae		1.00
Diptera	Chironomidae	Chironominae	218.83
Diptera	Chironomidae	Orthocladiinae	2499.98
Diptera	Chironomidae	Tanypodinae	51.34
Diptera	Empididae	Chelifera	24.19
Diptera	Empididae	Clinocera	13.06
Diptera	Psychodidae	Pericoma	2.00
Diptera	Simuliidae		2.00
Diptera	Simuliidae	Simulium	49.30
Diptera	Tabanidae	Tabanus	2.13
Diptera	Tipulidae		16.33
Diptera	Tipulidae	Antocha	74.37
Diptera	Tipulidae	Dicranota	8.28
Diptera	Tipulidae	Hesperoconopa	3.39
Diptera	Tipulidae	Hexatoma	7.07
Diptera	Tipulidae	Tipula	0.25
Ephemeroptera	Ameletidae	Ameletus	13.07
Ephemeroptera	Baetidae		1.69
Ephemeroptera	Baetidae	Baetis	225.48
Ephemeroptera	Baetidae	Centroptilum	1.60
Ephemeroptera	Ephemerellidae		70.43
Ephemeroptera	Ephemerellidae	Caudatella	1.00
Ephemeroptera	Ephemerellidae	Drunella	147.92
Ephemeroptera	Ephemerellidae	Drunella doddsi	48.17
Ephemeroptera	Heptageniidae		10.20
Ephemeroptera	Heptageniidae	Cinygmula	5.94
Ephemeroptera	Heptageniidae	Epeorus	7.92
Ephemeroptera	Heptageniidae	Ironodes	2.69
Ephemeroptera	Heptageniidae	Rhithrogena	24.12
Ephemeroptera	Isonychiidae	Isonychia	0.80
Ephemeroptera	Leptohyphidae	Tricorythodes	0.80
Ephemeroptera	Leptophlebiidae		14.00
Megaloptera	Corydalidae		17.01
Megaloptera	Corydalidae	Orohermes crepusculus	9.58
Megaloptera	Sialidae	Sialis	2.00
Odonata	Coenagrionidae		0.80
Odonata	Coenagrionidae	Argia	0.80
Odonata	Cordulegastridae	Cordulegaster dorsalis	0.13
Odonata	Gomphidae		2.73
Odonata	Gomphidae	Ophiogomphus occidentis	0.88
Plecoptera	Chloroperlidae		94.21
Plecoptera	Chloroperlidae	Sweltsa	49.18
Plecoptera	Leuctridae		4.39
Plecoptera	Nemouridae	Malenka	67.33
Plecoptera	Nemouridae	Zapada	63.53
Plecoptera	Nemouridae	Zapada cinctipes	5.33
Plecoptera	Peltoperlidae	Yoraperla	16.00

Taxonomic list, continued.

Order	Family	Subfamily/Genus/species	Average abundance
Plecoptera	Perlidae		58.69
Plecoptera	Perlidae	Calineuria californica	34.36
Plecoptera	Perlidae	Doroneuria	0.25
Plecoptera	Perlidae	Hesperoperla pacifica	12.34
Plecoptera	Perlodidae		150.90
Plecoptera	Perlodidae	Kogotus	10.00
Plecoptera	Perlodidae	Oroperla barbara	2.38
Plecoptera	Perlodidae	Perlinodes aurea	17.01
Plecoptera	Perlodidae	Skwala	10.15
Plecoptera	Pteronarcyidae	Pteronarcella regularis	4.00
Plecoptera	Pteronarcyidae	Pteronarcys	2.00
Trichoptera			2.25
Trichoptera	Apataniidae	Apatania	3.60
Trichoptera	Brachycentridae	Micrasema	271.90
Trichoptera	Glossosomatidae		6.60
Trichoptera	Glossosomatidae	Agapetus	13.29
Trichoptera	Glossosomatidae	Glossosoma	7.70
Trichoptera	Hydropsychidae		325.59
Trichoptera	Hydropsychidae	Arctopsyche	0.13
Trichoptera	Hydropsychidae	Cheumatopsyche	177.15
Trichoptera	Hydropsychidae	Hydropsyche	602.71
Trichoptera	Hydroptilidae		656.08
Trichoptera	Hydroptilidae	Leucotrichia	1.00
Trichoptera	Lepidostomatidae	Lepidostoma	16.16
Trichoptera	Limnephilidae		1.00
Trichoptera	Philopotamidae	Wormaldia	15.87
Trichoptera	Polycentropodidae	Polycentropus	1.82
Trichoptera	Rhyacophilidae	Rhyacophila	26.28
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	13.60
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	47.53
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata group	1.60
Trichoptera	Sericostomatidae	Gumaga	22.00
Class: Malacostraca			
Amphipoda	Hyalellidae	Hyalella azteca	0.80
Decapoda	Astacidae	Pacifastacus leniusculus	0.13
Phylum: Mollusca			
Class: Bivalvia			
Veneroida	Pisidiidae		2.00
Class: Gastropoda			
Basommatophora	Lymnaeidae		4.25
Basommatophora	Lymnaeidae	Radix auricularia	0.13
Basommatophora	Physidae	Physella	4.13
Basommatophora	Planorbidae	Gyraulus	40.00
Phylum: Nemata			1.00
Phylum: Platyhelminthes			
Class: Turbellaria			7.20
A total of 102 taxa were collected in 8 samples.			7548.32

List of taxa collected in 8 samples. Samples were collected between 9 September 2004 and 14 September 2004. Count is the total number of individuals identified and retained.

Taxon	Count
Arthropoda	
Arachnida	
Trombidiformes	154
Insecta	
Coleoptera	
Dytiscidae	5
Oreodytes	3
Elmidae	36
Ampumixis dispar	22
Cleptelmis addenda	56
Optioservus	244
Optioservus quadrimaculatus	112
Ordobrevia nubifera	1
Zaitzevia	98
Psephenidae	4
Eubrianax edwardsi	18
Diptera	
Ceratopogonidae	31
Probezzia	23
Chironomidae	1
Chironominae	154
Orthocladiinae	1782
Tanypodinae	44
Empididae	
Chelifera	18
Clinocera	9
Psychodidae	
Pericoma	1
Simuliidae	1
Simulium	35
Tabanidae	
Tabanus	2
Tipulidae	12
Antocha	62
Dicranota	10
Hesperoconopa	2
Hexatoma	14
Tipula	2
Ephemeroptera	
Ameletidae	
Ameletus	11
Baetidae	1
Baetis	192
Centroptilum	1
Ephemerellidae	69
Caudatella	1
Drunella	80
Drunella doddsi	33
Heptageniidae	9
Cinygmula	5
Epeorus	10
Ironodes	2

Taxonomic list, continued.

Taxon	Count
Rhithrogena	24
Isonychiidae	
Isonychia	1
Leptohyphidae	
Tricorythodes	1
Leptophlebiidae	7
Megaloptera	
Corydalidae	14
Orohermes crepusculus	25
Sialidae	
Sialis	1
Odonata	
Coenagrionidae	1
Argia	1
Cordulegastridae	
Cordulegaster dorsalis	1
Gomphidae	4
Ophiogomphus occidentis	7
Plecoptera	
Chloroperlidae	73
Sweltsa	38
Leuctridae	3
Nemouridae	
Malenka	40
Zapada	39
Zapada cinctipes	5
Peltoperlidae	
Yoraperla	8
Perlidae	41
Calineuria californica	82
Doroneuria	2
Hesperoperla pacifica	15
Perlodidae	138
Kogotus	5
Oroperla barbara	5
Perlinodes aurea	27
Skwala	16
Pteronarcyidae	
Pteronarcella regularis	2
Pteronarcys	1
Trichoptera	3
Apataniidae	
Apatania	3
Brachycentridae	
Micrasema	183
Glossosomatidae	8
Agapetus	9
Glossosoma	13
Hydropsychidae	258
Arctopsyche	1
Cheumatopsyche	242
Hydropsyche	657
Hydroptilidae	426
Leucotrichia	1

Taxonomic list, continued.

Taxon	Count
Lepidostomatidae	
Lepidostoma	12
Limnephilidae	1
Philopotamidae	
Wormaldia	23
Polycentropodidae	
Polycentropus	2
Rhyacophilidae	
Rhyacophila	20
Rhyacophila betteni group	14
Rhyacophila brunnea/vemna groups	56
Rhyacophila hyalinata group	1
Sericostomatidae	
Gumaga	11
Malacostraca	
Amphipoda	
Hyalellidae	
Hyalella azteca	1
Decapoda	
Astacidae	
Pacifastacus leniusculus	1
Mollusca	
Bivalvia	
Veneroida	
Pisidiidae	1
Gastropoda	
Basommatophora	
Lymnaeidae	4
Radix auricularia	1
Physidae	
Physella	3
Planorbidae	
Gyraulus	20
Nemata	1
Platyhelminthes	
Turbellaria	9
102 Taxa	5982 individuals

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Taxa Lists for Individual Samples

Taxonomic list and abundances of aquatic invertebrates collected 9 September 2004 at station PNFWALKER1, Little Grizzly Creek, Site 1, Plumas County, California. The sample was collected from riffle habitat using a Kick net. The total area sampled was 1.000 square meters. The sample identification number is 123901. The percentage of the sample that was identified and retained was 6% of the collected sample. A total of 667 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	160	
Class: Insecta					
Coleoptera	Elmidae		larvae	576	I
Coleoptera	Elmidae	Cleptelmis addenda	adult	16	
Coleoptera	Elmidae	Cleptelmis addenda	larvae	737	
Coleoptera	Elmidae	Optioservus	larvae	754	
Coleoptera	Elmidae	Optioservus quadrimaculatus	adult	337	
Coleoptera	Elmidae	Ordobrevia nubifera	adult	16	
Coleoptera	Elmidae	Zaitzevia	adult	48	
Coleoptera	Elmidae	Zaitzevia	larvae	32	
Coleoptera	Psephenidae		larvae	64	I
Coleoptera	Psephenidae	Eubrianax edwardsi	larvae	194	
Diptera	Ceratopogonidae	Probezzia	larvae	48	
Diptera	Chironomidae	Chironominae	larvae	208	
Diptera	Chironomidae	Orthocladiinae	larvae	2368	
Diptera	Chironomidae	Tanypodinae	larvae	16	
Diptera	Psychodidae	Pericoma	larvae	16	
Diptera	Simuliidae		pupae	16	
Diptera	Simuliidae	Simulium	larvae	128	
Diptera	Tabanidae	Tabanus	larvae	16	
Diptera	Tipulidae		pupae	16	
Diptera	Tipulidae	Hexatoma	larvae	34	
Ephemeroptera	Ameletidae	Ameletus	larvae	64	
Ephemeroptera	Ephemerellidae		larvae	32	I
Ephemeroptera	Ephemerellidae	Drunella	larvae	1040	I,U
Ephemeroptera	Ephemerellidae	Drunella doddsi	larvae	48	
Ephemeroptera	Heptageniidae		larvae	32	I
Ephemeroptera	Heptageniidae	Cinygmula	larvae	32	
Ephemeroptera	Heptageniidae	Rhithrogena	larvae	16	
Ephemeroptera	Leptophlebiidae		larvae	112	I
Megaloptera	Sialidae	Sialis	larvae	16	
Odonata	Cordulegastridae	Cordulegaster dorsalis	larvae	1	
Plecoptera	Chloroperlidae		larvae	112	I
Plecoptera	Chloroperlidae	Sweltsa	larvae	16	
Plecoptera	Nemouridae	Malenka	larvae	337	
Plecoptera	Nemouridae	Zapada	larvae	256	I
Plecoptera	Peltoperlidae	Yoraperla	larvae	128	
Plecoptera	Perlidae		larvae	32	I
Plecoptera	Perlidae	Calineuria californica	larvae	54	
Plecoptera	Perlodidae	Kogotus	larvae	80	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	larvae	32	I
Plecoptera	Pteronarcyidae	Pteronarcys	larvae	16	I
Trichoptera			larvae	16	I
Trichoptera	Brachycentridae	Micrasema	larvae	640	
Trichoptera	Glossosomatidae	Agapetus	larvae	16	
Trichoptera	Hydropsychidae		larvae	112	I
Trichoptera	Hydropsychidae	Hydropsyche	larvae	659	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	larvae	33	
Trichoptera	Sericostomatidae	Gumaga	larvae	176	
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae		adult	16	U
Class: Gastropoda					
Basommatophora	Lymnaeidae		adult	34	U
Basommatophora	Lymnaeidae	Radix auricularia	adult	1	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 123901.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Basommatophora	Physidae	Physella	adult	33	
Basommatophora	Planorbidae	Gyraulus	adult	320	
Total: 51 taxa				10312 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 September 2004 at station PNFWALKER2, Little Grizzly Creek, Site 2, Plumas County, California. The sample was collected from riffle habitat using a Kick net. The total area sampled was 1.000 square meters. The sample identification number is 123902. The percentage of the sample that was identified and retained was 9% of the collected sample. A total of 679 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	139	
Class: Insecta					
Coleoptera	Dytiscidae		larvae	11	
Coleoptera	Dytiscidae	Oreodytes	adult	32	
Coleoptera	Elmidae	Cleptelmis addenda	adult	43	
Coleoptera	Elmidae	Optioservus quadrimaculatus	adult	64	
Diptera	Ceratopogonidae		larvae	128	I
Diptera	Ceratopogonidae	Probezzia	larvae	32	
Diptera	Chironomidae	Chironominae	larvae	32	
Diptera	Chironomidae	Orthocladiinae	larvae	5401	
Diptera	Chironomidae	Tanypodinae	larvae	111	
Diptera	Empididae	Chelifera	larvae	160	
Diptera	Empididae	Clinocera	larvae	53	
Diptera	Tipulidae	Antocha	larvae	21	
Diptera	Tipulidae	Dicranota	larvae	22	
Diptera	Tipulidae	Tipula	larvae	2	
Ephemeroptera	Baetidae	Baetis	larvae	21	
Plecoptera	Perlodidae		larvae	203	I
Trichoptera	Brachycentridae	Micrasema	larvae	11	
Trichoptera	Hydropsychidae		larvae	43	I
Trichoptera	Hydropsychidae	Hydropsyche	larvae	21	
Trichoptera	Hydroptilidae		larvae	224	I
Trichoptera	Rhyacophilidae	Rhyacophila	larvae	96	I
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	larvae	100	
Total: 23 taxa				6968 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 10 September 2004 at station PNFWALKER3, Little Grizzly Creek, Site 3, Plumas County, California. The sample was collected from riffle habitat using a Kick net. The total area sampled was 1.000 square meters. The sample identification number is 123903. The percentage of the sample that was identified and retained was 8% of the collected sample. A total of 757 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	38	
Class: Insecta					
Coleoptera	Dytiscidae		larvae	51	I
Coleoptera	Elmidae	Cleptelmis addenda	adult	13	
Coleoptera	Elmidae	Optioservus quadrimaculatus	adult	115	
Diptera	Ceratopogonidae		larvae	243	U
Diptera	Ceratopogonidae	Probezzia	larvae	13	
Diptera	Chironomidae	Chironominae	larvae	78	
Diptera	Chironomidae	Orthocladiinae	larvae	2524	
Diptera	Chironomidae	Tanypodinae	larvae	158	
Diptera	Empididae	Chelifera	larvae	26	
Diptera	Empididae	Clinocera	larvae	13	
Diptera	Simuliidae	Simulium	larvae	90	
Diptera	Tipulidae		pupae	77	
Diptera	Tipulidae	Antocha	larvae	299	
Diptera	Tipulidae	Dicranota	larvae	1	
Diptera	Tipulidae	Hexatoma	larvae	2	
Ephemeroptera	Baetidae	Baetis	larvae	193	
Ephemeroptera	Baetidae	Centroptilum	larvae	13	
Ephemeroptera	Ephemerellidae	Drunella doddsi	larvae	13	
Megaloptera	Corydalidae	Orohermes crepusculus	larvae	26	
Plecoptera	Chloroperlidae		larvae	115	I
Plecoptera	Chloroperlidae	Sweltsa	larvae	26	
Plecoptera	Nemouridae	Malenka	larvae	90	
Plecoptera	Nemouridae	Zapada	larvae	38	I
Plecoptera	Perlidae		larvae	51	I
Plecoptera	Perlidae	Calineuria californica	larvae	30	
Plecoptera	Perlodidae		larvae	102	I
Plecoptera	Perlodidae	Oroperla barbara	larvae	1	R1
Trichoptera			pupae	1	U
Trichoptera	Brachycentridae	Micrasema	larvae	26	
Trichoptera	Hydropsychidae		larvae	38	I
Trichoptera	Hydropsychidae	Hydropsyche	larvae	154	
Trichoptera	Hydroptilidae		larvae	4353	I,U
Trichoptera	Rhyacophilidae	Rhyacophila	larvae	26	D
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	larvae	56	

Total: 35 taxa				9091 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 10 September 2004 at station PNFWALKER4, Little Grizzly Creek, Site 4, Plumas County, California. The sample was collected from riffle habitat using a Kick net. The total area sampled was 1.000 square meters. The sample identification number is 123904. The percentage of the sample that was identified and retained was 8% of the collected sample. A total of 725 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	26	
Class: Insecta					
Coleoptera	Elmidae	Optioservus quadrimaculatus	adult	51	
Diptera	Ceratopogonidae	Probezzia	larvae	14	
Diptera	Chironomidae	Chironominae	larvae	65	
Diptera	Chironomidae	Orthocladiinae	larvae	5376	
Diptera	Chironomidae	Tanypodinae	larvae	39	
Diptera	Empididae	Clinocera	larvae	38	
Diptera	Simuliidae	Simulium	larvae	64	
Diptera	Tabanidae	Tabanus	larvae	1	
Diptera	Tipulidae		pupae	13	
Diptera	Tipulidae	Antocha	larvae	91	
Diptera	Tipulidae	Dicranota	larvae	13	
Diptera	Tipulidae	Hexatoma	larvae	3	
Ephemeroptera	Baetidae	Baetis	larvae	219	
Ephemeroptera	Ephemerellidae		larvae	243	I
Ephemeroptera	Ephemerellidae	Drunella	larvae	51	I,U
Ephemeroptera	Ephemerellidae	Drunella doddsi	larvae	51	
Megaloptera	Corydalidae		larvae	13	I
Megaloptera	Corydalidae	Orohermes crepusculus	larvae	2	
Plecoptera	Chloroperlidae		larvae	51	I
Plecoptera	Chloroperlidae	Sweltsa	larvae	52	
Plecoptera	Nemouridae	Malenka	larvae	64	
Plecoptera	Nemouridae	Zapada	larvae	166	I
Plecoptera	Perlidae		larvae	77	I
Plecoptera	Perlidae	Calineuria californica	larvae	33	
Plecoptera	Perlidae	Doroneuria	larvae	1	
Plecoptera	Perlodidae		larvae	77	I
Plecoptera	Perlodidae	Oroperla barbara	larvae	1	
Plecoptera	Perlodidae	Perlinodes aurea	larvae	3	
Trichoptera	Apataniidae	Apatania	larvae	13	
Trichoptera	Brachycentridae	Micrasema	larvae	115	
Trichoptera	Glossosomatidae	Agapetus	larvae	1	
Trichoptera	Hydropsychidae		larvae	256	I
Trichoptera	Hydropsychidae	Hydropsyche	larvae	520	
Trichoptera	Hydroptilidae		larvae	640	I,U
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	larvae	52	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	larvae	137	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata group	larvae	13	

Total: 38 taxa				8646 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 13 September 2004 at station PNFWALKER5, Little Grizzly Creek, Site 5, Plumas County, California. The sample was collected from riffle habitat using a Kick net. The total area sampled was 1.000 square meters. The sample identification number is 123905. The percentage of the sample that was identified and retained was 13% of the collected sample. A total of 767 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	168	
Class: Insecta					
Coleoptera	Elmidae	Ampumixis dispar	larvae	16	
Coleoptera	Elmidae	Optioservus	larvae	98	
Coleoptera	Elmidae	Optioservus quadrimaculatus	adult	177	
Coleoptera	Elmidae	Zaitzevia	larvae	8	
Coleoptera	Elmidae	Zaitzevia	adult	24	U
Diptera	Ceratopogonidae	Probezzia	larvae	80	
Diptera	Chironomidae		pupae	8	
Diptera	Chironomidae	Chironominae	larvae	360	
Diptera	Chironomidae	Orthocladiinae	larvae	1912	
Diptera	Chironomidae	Tanypodinae	larvae	32	
Diptera	Empididae	Chelifera	larvae	8	
Diptera	Simuliidae	Simulium	larvae	40	
Diptera	Tipulidae		pupae	16	
Diptera	Tipulidae		larvae	1	U
Diptera	Tipulidae	Antocha	larvae	41	
Diptera	Tipulidae	Hexatoma	larvae	3	
Ephemeroptera	Ameletidae	Ameletus	larvae	25	
Ephemeroptera	Baetidae	Baetis	larvae	299	
Ephemeroptera	Ephemerellidae		larvae	16	I
Ephemeroptera	Ephemerellidae	Caudatella	larvae	8	I
Ephemeroptera	Ephemerellidae	Drunella	larvae	40	I,U
Ephemeroptera	Ephemerellidae	Drunella doddsi	larvae	40	
Ephemeroptera	Heptageniidae		larvae	8	
Ephemeroptera	Heptageniidae	Ironodes	larvae	8	
Megaloptera	Corydalidae		larvae	41	I
Megaloptera	Corydalidae	Orohermes crepusculus	larvae	40	
Plecoptera	Chloroperlidae		larvae	130	I
Plecoptera	Chloroperlidae	Sweltsa	larvae	137	
Plecoptera	Leuctridae		larvae	8	I
Plecoptera	Nemouridae	Malenka	larvae	40	
Plecoptera	Nemouridae	Zapada	larvae	41	I
Plecoptera	Perlidae		larvae	48	I
Plecoptera	Perlidae	Calineuria californica	larvae	85	
Plecoptera	Perlodidae		larvae	32	I
Plecoptera	Perlodidae	Oroperla barbara	larvae	17	
Plecoptera	Perlodidae	Perlinodes aurea	larvae	101	
Plecoptera	Perlodidae	Skwala	larvae	16	
Trichoptera			pupae	1	U
Trichoptera	Apataniidae	Apatania	larvae	16	
Trichoptera	Brachycentridae	Micrasema	larvae	482	
Trichoptera	Glossosomatidae		larvae	8	I
Trichoptera	Glossosomatidae	Agapetus	larvae	8	
Trichoptera	Glossosomatidae	Glossosoma	larvae	2	
Trichoptera	Hydropsychidae		larvae	256	I
Trichoptera	Hydropsychidae	Hydropsyche	larvae	521	
Trichoptera	Hydroptilidae		larvae	8	I
Trichoptera	Lepidostomatidae	Lepidostoma	larvae	48	
Trichoptera	Limnephilidae		pupae	8	
Trichoptera	Rhyacophilidae	Rhyacophila	larvae	48	I
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	larvae	41	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	larvae	54	
Phylum: Nemata			adult	8	

Total: 51 taxa				5681 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 13 September 2004 at station PNFWALKER6, Little Grizzly Creek, Site 6, Plumas County, California. The sample was collected from riffle habitat using a Kick net. The total area sampled was 1.000 square meters. The sample identification number is 123906. The percentage of the sample that was identified and retained was 7% of the collected sample. A total of 768 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	1369	
Class: Insecta					
Coleoptera	Elmidae	Ampumixis dispar	larvae	246	
Coleoptera	Elmidae	Optioservus	larvae	123	
Coleoptera	Elmidae	Optioservus quadrimaculatus	adult	231	
Coleoptera	Elmidae	Zaitzevia	adult	27	
Coleoptera	Elmidae	Zaitzevia	larvae	14	
Diptera	Ceratopogonidae	Probezzia	larvae	41	
Diptera	Chironomidae	Chironominae	larvae	921	
Diptera	Chironomidae	Orthocladiinae	larvae	1592	
Diptera	Chironomidae	Tanypodinae	larvae	41	
Diptera	Simuliidae	Simulium	larvae	14	
Diptera	Tipulidae	Antocha	larvae	14	
Diptera	Tipulidae	Dicranota	larvae	27	
Diptera	Tipulidae	Dicranota	larvae	3	
Diptera	Tipulidae	Hesperoconopa	larvae	27	
Diptera	Tipulidae	Hexatoma	larvae	15	
Ephemeroptera	Ameletidae	Ameletus	larvae	16	
Ephemeroptera	Baetidae		larvae	14	I
Ephemeroptera	Baetidae	Baetis	larvae	601	
Ephemeroptera	Ephemerellidae	Drunella	larvae	28	U
Ephemeroptera	Ephemerellidae	Drunella doddsi	larvae	233	
Ephemeroptera	Heptageniidae	Cinygmula	larvae	16	
Ephemeroptera	Heptageniidae	Ironodes	larvae	14	
Ephemeroptera	Heptageniidae	Rhithrogena	larvae	68	
Megaloptera	Corydalidae		larvae	82	I
Megaloptera	Corydalidae	Orohermes crepusculus	larvae	9	
Plecoptera	Chloroperlidae		larvae	219	I
Plecoptera	Chloroperlidae	Sweltsa	larvae	163	
Plecoptera	Leuctridae		larvae	27	I
Plecoptera	Nemouridae	Zapada cinctipes	larvae	43	
Plecoptera	Perlidae		larvae	261	I
Plecoptera	Perlidae	Calineuria californica	larvae	65	
Plecoptera	Perlidae	Doroneuria	larvae	1	
Plecoptera	Perlidae	Hesperoperla pacifica	larvae	68	
Plecoptera	Perlodidae		larvae	54	I
Plecoptera	Perlodidae	Perlinodes aurea	larvae	32	
Trichoptera	Brachycentridae	Micrasema	larvae	854	
Trichoptera	Glossosomatidae	Agapetus	larvae	81	
Trichoptera	Glossosomatidae	Glossosoma	larvae	1	
Trichoptera	Hydropsychidae		larvae	1207	I
Trichoptera	Hydropsychidae	Arctopsyche	larvae	1	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	341	
Trichoptera	Lepidostomatidae	Lepidostoma	larvae	81	
Trichoptera	Polycentropodidae	Polycentropus	larvae	15	
Trichoptera	Rhyacophilidae	Rhyacophila	larvae	41	I
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	larvae	16	

Total: 44 taxa				9352 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 14 September 2004 at station PNFWALKER7, Indian Creek, Site 1, Plumas County, California. The sample was collected from riffle habitat using a Kick net. The total area sampled was 1.000 square meters. The sample identification number is 123907. The percentage of the sample that was identified and retained was 16% of the collected sample. A total of 817 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	6	
Class: Insecta					
Coleoptera	Elmidae	Optioservus	larvae	350	
Coleoptera	Elmidae	Optioservus quadrimaculatus	adult	176	
Coleoptera	Elmidae	Zaitzevia	larvae	96	
Coleoptera	Elmidae	Zaitzevia	adult	98	U
Diptera	Chironomidae	Chironominae	larvae	38	
Diptera	Chironomidae	Orthocladiinae	larvae	179	
Diptera	Chironomidae	Tanypodinae	larvae	6	
Diptera	Simuliidae	Simulium	larvae	51	
Diptera	Tipulidae	Antocha	larvae	1	
Ephemeroptera	Baetidae	Baetis	larvae	124	
Ephemeroptera	Ephemerellidae		larvae	248	I
Ephemeroptera	Heptageniidae		larvae	26	I
Ephemeroptera	Heptageniidae	Epeorus	larvae	39	
Ephemeroptera	Heptageniidae	Rhithrogena	larvae	85	
Ephemeroptera	Isonychiidae	Isonychia	larvae	6	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	6	
Odonata	Coenagrionidae		larvae	6	I
Odonata	Coenagrionidae	Argia	larvae	6	I
Odonata	Gomphidae		larvae	14	I
Odonata	Gomphidae	Ophiogomphus occidentis	larvae	7	R4
Plecoptera	Chloroperlidae		larvae	38	I
Plecoptera	Nemouridae	Zapada	larvae	6	I
Plecoptera	Perlidae	Hesperoperla pacifica	larvae	2	
Plecoptera	Perlodidae		larvae	147	I
Plecoptera	Perlodidae	Skwala	larvae	23	
Trichoptera	Glossosomatidae		larvae	45	I
Trichoptera	Glossosomatidae	Glossosoma	larvae	59	
Trichoptera	Hydropsychidae		larvae	493	I
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	670	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	1314	
Trichoptera	Philopotamidae	Wormaldia	larvae	34	
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	6	
Phylum: Platyhelminthes					
Class: Turbellaria			adult	58	

Total: 33 taxa				4466 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 14 September 2004 at station PNFWALKER8, Indian Creek, Site 2, Plumas County, California. The sample was collected from riffle habitat using a Kick net. The total area sampled was 1.000 square meters. The sample identification number is 123908. The percentage of the sample that was identified and retained was 13% of the collected sample. A total of 802 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	24	
Class: Insecta					
Coleoptera	Elmidae	Cleptelmis addenda	larvae	24	
Coleoptera	Elmidae	Optioservus	larvae	882	
Coleoptera	Elmidae	Zaitzevia	adult	136	U
Coleoptera	Elmidae	Zaitzevia	larvae	275	
Coleoptera	Psephenidae	Eubrianax edwardsi	larvae	25	
Diptera	Ceratopogonidae	Probezzia	larvae	8	
Diptera	Chironomidae	Chironominae	larvae	48	
Diptera	Chironomidae	Orthocladiinae	larvae	648	
Diptera	Chironomidae	Tanypodinae	larvae	8	
Diptera	Simuliidae	Simulium	larvae	8	
Diptera	Tipulidae		pupae	8	
Diptera	Tipulidae	Antocha	larvae	128	
Ephemeroptera	Baetidae	Baetis	larvae	347	
Ephemeroptera	Ephemerellidae		larvae	24	I
Ephemeroptera	Ephemerellidae	Drunella	larvae	24	U
Ephemeroptera	Heptageniidae		larvae	16	I
Ephemeroptera	Heptageniidae	Epeorus	larvae	24	
Ephemeroptera	Heptageniidae	Rhithrogena	larvae	24	
Odonata	Gomphidae		larvae	8	I
Plecoptera	Chloroperlidae		larvae	88	I
Plecoptera	Nemouridae	Malenka	larvae	8	
Plecoptera	Perlidae	Calineuria californica	larvae	9	
Plecoptera	Perlidae	Hesperoperla pacifica	larvae	29	
Plecoptera	Perlodidae		larvae	592	I
Plecoptera	Perlodidae	Skwala	larvae	42	
Trichoptera	Brachycentridae	Micrasema	larvae	48	
Trichoptera	Hydropsychidae		larvae	200	I
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	747	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	1292	
Trichoptera	Hydroptilidae		larvae	24	I
Trichoptera	Hydroptilidae	Leucotrichia	larvae	8	
Trichoptera	Philopotamidae	Wormaldia	larvae	93	
Class: Malacostraca					
Decapoda	Astacidae	Pacifastacus leniusculus	adult	1	

Total: 33 taxa				5870 individuals	

BIOASSESSMENT 2004

PERIPHYTON (ALGAE) COMMUNITY REPORT

EFFECT OF THE WALKER MINE TAILINGS ON PERIPHYTON IN LITTLE GRIZZLY CREEK AND INDIAN CREEK, PLUMAS NATIONAL FOREST CALIFORNIA 2002-2004

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Summary

In late summer or early fall of 2002, 2003, and 2004, periphyton samples were collected from 6 sites in Little Grizzly Creek and 2 sites in Indian Creek on the Plumas National Forest in northern California as part of the Walker Mine Tailings Project. Samples were collected following the U.S. Forest Service's Pacific Southwest Region Stream Bioassessment Protocols and processed and analyzed using standard methods for periphyton. The results were evaluated using modified USEPA rapid bioassessment protocols for wadeable streams and compared to biocriteria established for streams in the Rocky Mountain Region. The purpose of this report is to use data generated from 3 years of sampling to determine the degree of impairment at each of the sample sites, to determine the likely cause or causes of impairment at sites where impairment is evident, and to compare and contrast the 2004 results with those reported in 2002 and 2003.

Periphyton results for 2004 were similar to those recorded in 2002 and 2003. A combination of possible acid waters, elevated concentrations of heavy metals, elevated levels of organic nitrogen, and apparent sedimentation caused moderate to severe impairment of aquatic life at sites 2, 3, 4, and 5 on Little Grizzly Creek. These sites had low diatom species richness and diversity and elevated numbers of highly motile, pollution tolerant, and morphologically defective diatoms. As in previous years, both sites on Indian Creek had very similar algal floras, indicating that any pollutants discharged by Little Grizzly Creek had little or no effect.

Several key conclusions may be drawn from the 3 years of periphyton sampling. **First,** aquatic life uses at sites 2 through 5 on **Little Grizzly Creek** are moderately to severely impaired and biological integrity ranges from fair to poor. The degree and specific cause of impairment and the site of maximum impairment varied from year to year.

Second, the probable causes of impairment at these sites are (1) (acid?) mine drainage and associated heavy metals; (2) organic (mostly nitrogen) enrichment; and (3) apparent excessive sedimentation. Growths of nitrogen-fixing cyanobacteria and associated bacterial slimes may be the source of the organic matter detected by the nitrogen heterotrophic diatoms that were abundant at sites 2, 3, and 4.

Third, a significant amount of recovery occurred between sites 5 and 6 on Little Grizzly Creek. Site 6 is relatively unimpaired and provides full support for aquatic life uses. **Fourth,** site 1 on Little Grizzly Creek is also relatively unimpaired and serves well as a control site.

The **fifth** key conclusion that may be drawn from this study is that the periphyton community of **Indian Creek** shows little or no effect from pollutants discharged by Little Grizzly Creek. Diatom associations above and below the confluence of Little Grizzly Creek were virtually identical in all three years. The largest impact to **Indian Creek** occurred in 2004, when the lowest algal genus richness and diversity were recorded in Little Grizzly Creek, when certain pollution-sensitive algal genera were absent from both streams, when there was a significant decrease in the number of non-diatom algal genera from above to below the mouth of Little Grizzly Creek, and when the lowest diatom similarity index between sites 7 and 8 was recorded. Nevertheless, diatom metrics suggest full support of aquatic life uses and good biological integrity at both sites on **Indian Creek** in all three years of the study.

Introduction

This report evaluates the biological integrity[1] of periphyton communities at selected sites in Little Grizzly Creek and Indian Creek on the Plumas National Forest in northern California. The purpose of this report is to provide information that will help the Plumas National Forest and the State of California identify which of these stream sites is impaired, estimate the level of impairment and the support of aquatic life uses at each site, and determine the likely cause or causes of impairment at each impaired site.

Evaluation of aquatic life use support in this report is based on the species composition and structure of periphyton (benthic algae, phytobenthos) communities at eight sites that were sampled in September or October of 2002, 2003, and 2004. Results for the 2004 samples are presented here for the first time. They are compared and contrasted with results from the 2002 and 2003 samples, which were reported earlier (Bahls 2003, 2004).

Periphyton is a diverse assortment of simple photosynthetic organisms called algae that live attached to or in close proximity of the stream bottom. The periphyton community is a basic biological component of all aquatic ecosystems. Periphyton accounts for much of the primary production and biological diversity in mountain streams (Bahls et al. 1992). Plafkin et al. (1989) and Barbour et al. (1999) list several advantages of using periphyton in biological assessments.

Project Area and Sampling Sites

The project area is located within the Sierra Nevada Ecoregion of the United States (Omernik 1986) in Plumas County, California. Vegetation is mainly mixed conifer forest (Bailey 1995). The main land uses in the Little Grizzly Creek and Indian Creek watersheds are grazing, logging, mining, agriculture, and recreation. Little Grizzly Creek is a tributary of Indian Creek, which is a tributary of the East Branch North Fork Feather River (HUC 18020122).

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[1] *Biological integrity* is defined as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region" (Karr and Dudley 1981).

Periphyton samples were collected at six sites on Little Grizzly Creek and two sites on Indian Creek, one above and one below the confluence with Little Grizzly Creek (Table 1). Elevations at the sample sites range from 5800 feet at the uppermost site on Little Grizzly Creek to 3670 feet at the lower site on Indian Creek. Little Grizzly Creek is a 3rd order stream and Indian Creek is a 4th order stream (Strahler 1957). Based on pebble count data, the modal category for substrate particle size at each site ranged from 64 mm to >180 mm diameter (Clifton 2003). Values for selected environmental variables that were measured or estimated in the field at the same time that the 2004 periphyton samples were collected are presented in Table 2.

Methods

Periphyton samples were collected using the USDA Forest Service's Pacific Southwest Region Stream Bioassessment Protocols (Version 2001-1). For each site, a reach of not less than 500 m was established. Within this reach, four fast-water (riffle) habitats were selected in sequence, beginning near the downstream end of the reach. Two rocks in the 15-20 cm diameter size class were sampled in each riffle, for a total of eight rocks from the reach. Periphyton material was brushed or scraped from a delimited area on the surface of each rock and composited into a single sample bottle. The total substrate area represented by each composite periphyton sample was 96.0 cm^2. Samples were preserved with 10% formalin. Clifton (2003) provided field notes for the 2003 biological sampling event.

The samples were examined to estimate the relative abundance of cells and ordinal rank by biovolume of diatoms and genera of soft (non-diatom) algae according to the method described in Bahls (1993). Soft algae were identified using Smith (1950), Prescott (1962, 1978), John et al. (2002), and Wehr and Sheath (2003). These books also served as references on the ecology of the soft algae, along with Palmer (1969, 1977).

After the identification of soft algae, the raw periphyton samples were cleaned of organic matter using sulfuric acid, potassium dichromate, and hydrogen peroxide. Then permanent diatom slides were prepared using Naphrax™, a high refractive index mounting medium, following *Standard Methods for the Examination of Water and Wastewater* (APHA 1998). Between 400 and 500 diatom cells (800 to 1000 valves) were counted at random and identified to species. Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b) were the main taxonomic references for the diatoms. Diatom naming conventions followed those adopted by the Academy of Natural Sciences for USGS NAWQA samples (Morales and Potapova 2000). Van Dam et al. (1994) was the main ecological reference for the diatoms.

The diatom proportional counts were used to generate an array of diatom association metrics. A metric is a characteristic of the biota that changes in some predictable way with increased human influence (Barbour et al. 1999). Diatoms are particularly useful in generating metrics because there is a wealth of information available in the literature regarding the pollution tolerances and water quality preferences of common diatom species (e.g., Lowe 1974, Beaver 1981, Van Dam et al. 1994, Lange-Bertalot 1996).

Values for selected metrics were compared to biocriteria (numeric thresholds) developed for streams in the Rocky Mountain ecoregions of western Montana (Table 3). These criteria are based on metric values measured in least-impaired reference streams (Bahls et al. 1992) and on metric values measured in streams that are impaired by various sources and causes of pollution (Bahls 1993). The biocriteria in Table 3 were established for samples collected during the summer field season (June 21-September 21) in the Rocky Mountains. Because the Plumas N. F. samples were collected in the Sierras and sometimes outside the summer field season, the criteria and impairment levels in Table 3 may not be appropriate for evaluating these data.

The criteria in Table 3 distinguish among four levels of stress or impairment and three levels of aquatic life use support: (1) no impairment or only minor impairment (full support); (2) moderate impairment (partial support); and (3) severe impairment (non-support). These impairment levels correspond to excellent, good, fair, and poor biological integrity, respectively. In cold, high-gradient mountain streams, natural stressors will sometimes mimic the effects of man-caused impairment on some metric values.

An experimental metric—the metals index—was introduced in the report on the 2003 samples (Bahls 2004). This index is the total percentage of diatoms in a sample that represent species that are known to tolerate elevated concentrations of heavy metals. The list of species used to calculate the metals index for the 2004 samples (Table 4) is smaller than the list used for the 2003 samples. Several cosmopolitan, pollution-sensitive species were removed from the list: *Achnanthidium minutissimum, Diatoma hiemalis, Diatoma mesodon, Hannaea arcus, Staurosira construens, Staurosirella leptostauron,* and *Staurosirella pinnata*. These species tolerate small concentrations of heavy metals but also respond positively to natural stream features, such as cold water, low light, low nutrients, steep or gentle gradients, and fast or slow current velocities. Removing these species should make the index more responsive to heavy metals and less sensitive to natural stressors. Nevertheless, all of the species that remain on the list also tolerate elevated levels of organic matter, so sometimes it may not be clear whether they are responding to metals or organic enrichment.

Quality Assurance

Several steps were taken to assure that the study results are accurate and reproducible. Upon receipt of the samples, station and sample attribute data were recorded in the Montana Diatom Database and the samples were assigned a unique number, e.g., 2580-03. The first part of this number (2580) designates the sampling site (Little Grizzly Creek Site 1) and the second part (03) designates the number of periphyton samples that that have been collected at this site for which data have been entered into the Montana Diatom Database.

Sample observations and analyses of soft (non-diatom) algae were recorded in a lab notebook along with information on the sample label. A portion of the raw sample was used to make duplicate diatom slides. The slide used for the diatom proportional count will be deposited in the Montana Diatom Collection at the University of Montana Herbarium in Missoula. The duplicate slide will be retained at the offices of *Hannaea* in Helena, Montana. Diatom proportional counts have been entered into the Montana Diatom Database.

Results and Discussion

Periphyton results are presented in Tables 5 and 6 and Figures 1 through 7, which are located near the end of this report following the references section. Accompanying this report is a CD containing raw algae counts and computed diatom metrics for all three years of the study, as well as electronic copies of this report and reports prepared for the 2002 and 2003 samples.

Non-Diatom Algae (2004)

Little Grizzly Creek. The periphyton community in Little Grizzly Creek was dominated by diatoms and by cyanobacteria in 2004 (Table 5), as it was in both 2002 and 2003. Some of the cyanobacteria or blue-green algae (*Calothrix, Nostoc, Tolypothrix*) have heterocysts and are capable of fixing atmospheric nitrogen under aerobic conditions, suggesting that nitrogen is the limiting *inorganic* nutrient in this stream, particularly at the four upstream stations.

In 2004, green algae (Chlorophyta) were restricted to sites 1 and 2, where they were encountered only occasionally (Table 5). Unlike previous years, green algae were absent from site 6 in 2004. In fact, diatoms were the only algae found at sites 5 and 6 in 2004. The pollution sensitive yellow-green algae *Tribonema* and *Vaucheria,* which were found here in previous years, were absent from Little Grizzly Creek (and Indian Creek) in 2004.

The number of non-diatom genera declined in a downstream direction in 2004 (Table 5). Similar downstream declines were observed in previous years (Figure 1). A downstream decline in genus richness probably reflects accumulating stress from pollution sources in Little Grizzly Creek. Except for site 1, algal genus richness was lower in 2004 than in the previous two years.

Indian Creek. Diatoms and green algae dominated the periphyton community in Indian Creek above Little Grizzly Creek, and bluegreens (mostly *Nostoc* spp.) were common (Table 5). Diatoms and green algae were much reduced in numbers and in diversity below Little Grizzly Creek. The pollution-sensitive genera *Tribonema* and *Tolypothrix,* observed in Indian Creek in previous years, were missing in 2004. *Nostoc*, a pollution-sensitive, nitrogen-fixing cyanobacterium, was common above Little Grizzly Creek but found only occasionally downstream (Table 5). The downstream site supported only half the number of genera (5) of non-diatom algae as the upstream site (10). The five genera at the downstream site was the lowest number of non-diatom algae recorded here in the three years of sampling (Figure 1).

The above findings—especially the absence of certain sensitive taxa and the decline in algal genus richness—suggest that overall stress on the periphyton community of both streams was greater in 2004 than in either 2002 or 2003.

Diatoms (2004)

Of the 18 major diatom species found in Little Grizzly Creek and Indian Creek in 2004, 11 are sensitive to organic pollution, 5 are somewhat tolerant of organic pollution, and 2 are most tolerant of organic pollution (Table 6). The two major species that are most tolerant of organic pollution were *Nitzschia palea* and *Navicula minima*, which were most abundant at sites 2 and 3. *Nitzschia palea* is an obligate nitrogen heterotroph and requires large concentrations of organic nitrogen for optimum growth and population development. *Navicula minima* is an eutraphentic species and a faculatative nitrogen heterotroph that tolerates moderately heavy loads of organic matter (Van Dam et al. 1994). Both species tolerate elevated concentrations of heavy metals.

Another major species, especially in Little Grizzly Creek, was *Achnanthidium minutissimum* (synonym: *Achnanthes minutissima*). As in previous years, this was again the dominant diatom species at site 5 and a co-dominant species at site 2 (Table 6). *Achnanthidium minutissimum* is a cosmopolitan species with very small cells that attach to hard substrates by a short stalk. Although sensitive to organic pollution and an indicator of low concentrations of inorganic phosphorus, *A. minutissimum* also tolerates small to moderate concentrations of heavy metals and a wide range of pH values. Because of its attached growth form and low profile, it is resistant to physical and biological disturbance in the form of scour and grazing by macroinvertebrates. It is a pioneer species that prospers on rocky substrates in high gradient reaches that have moderate to fast current velocities.

Cocconeis placentula is another major species that is sensitive to organic pollution, but unlike *Achnanthidium minutissimum* it is also sensitive to heavy metals. As in 2003, *Cocconeis placentula* was the dominant diatom species at site 1 and a co-dominant species at site 6, but it was uncommon or absent at stations 2 through 5 (Table 6). *Nitzschia dissipata*, the dominant species at site 4 in both 2003 and 2004, prefers well-oxygenated, alkaline waters with moderate concentrations of inorganic nutrients (Van Dam et al. 1994).

Rhopalodia gibba, which was most abundant at site 3 in 2004 (Table 6), is a nitrogen autotroph and an eutraphentic species. It commonly harbors nitrogen-fixing cyanobacteria as endosymbionts, enabling this combination of taxa to fix atmospheric (molecular) nitrogen into ammonia and amino acids (Stewart et al. 1980).

Appearing as a major species at site 2 in 2004 and 2003 (but not in 2002) was *Pinnularia appendiculata*. This species ranked fourth in abundance at site 2 and accounted for 5.5% of the diatom cells at this station (Table 6). *Pinnularia appendiculata* is most often found in salt-rich, mineralized waters that have large concentrations of electrolytes (Krammer 2000).

All of the major diatom species in Table 6 are cosmopolitan in distribution and found in disturbed watersheds of temperate regions worldwide. Little Grizzly Creek and Indian Creek supported few unknown diatom species and no recognized endemic species, which would be expected in more pristine habitats.

All of the sites except site 1 in Little Grizzly Creek supported at least a few teratological (physically abnormal) diatom cells (Table 6, Figure 5). Little Grizzly Creek site 3 supported the largest percentage (2.66%). Small numbers of abnormal cells (1-4 abnormal cells per count of 400 cells) may indicate low background concentrations of heavy metals, which may result from the mineralized geology of the watershed. Larger numbers of abnormal cells (>4 cells per 400 counted) usually indicate elevated concentrations of heavy metals (McFarland et al. 1997), but they may also result from exposure to other toxins or environmental stressors.

Little Grizzly Creek. A somewhat elevated percentage of motile diatoms suggests that **site 1** on Little Grizzly Creek is **slightly impaired by sedimentation** (Table 6). All other metrics examined for this site indicate no impairment, excellent biological integrity, and full support of aquatic life uses when compared to periphyton communities at least-impaired reference sites in the Rocky Mountain ecoregions of Montana in summer. The most abundant species at **site 1** (*Cocconeis placentula*) is sensitive to metals and organic pollution. No abnormal diatom valves were observed at **site 1**.

As in previous years, a dramatic change in diatom composition occurred between sites 1 and 2, which shared only 22% of their diatom assemblages (Table 6). *Cocconeis placentula* almost disappeared at **site 2** and was replaced as the major species by *Achnanthidium minutissimum, Navicula minima, Nitzschia palea* and *Pinnularia appendiculata.* The large percentage of pollution-tolerant species (*Navicula minima* and *Nitzschia palea*) resulted in a significant drop in the pollution index (Table 6). In 2004 there was a large decline in the number of diatom species and Shannon species diversity between sites 1 and 2, as there was in 2002 and 2003. **Site 2** also supported a few teratological diatom cells. The low species diversity and high level of disturbance at **site 2** were probably caused by a combination of higher stream gradient (Table 2) and elevated organic matter and/or heavy metals. The percentage of motile diatoms suggests about the same level of sedimentation at site 2 as at site 1. Overall, diatom metrics indicate minor impairment at **site 2**, but values for the pollution index and siltation index were very close to the threshold for **moderate impairment and partial support of aquatic life uses.**

A significant but smaller change occurred between sites 2 and 3. These sites shared about half of their diatom assemblages (Table 6). The sedimentation index at **site 3** increased into the range of **moderate impairment**. The percentage of abnormal diatom cells was much larger at **site 3** (2.66%) than at sites 1 or 2.

Diatom species richness at **site 3** continued its decline from site 1. *Nitzschia palea* remained a major species and indicates continued input of nitrogen-rich organic nutrients. Growths of nitrogen-fixing cyanobacteria and associated true bacteria may be the source of these organic nutrients. Such growths are common in circumneutral to alkaline, nitrogen-limited systems. The ammonia and amino acids generated by the cyanobacteria and released upon their death and decay would be available as nutrient sources for bacteria and heterotrophic diatoms (Grant Mitman, Professor of Biology, Montana College of Mineral Science and Technology, personal communication). The pollution index at **site 3** was slightly smaller than it was at site 2 and even closer to the threshold for moderate impairment and partial support of aquatic life uses.

A smaller change occurred between sites 3 and 4, which shared over 60% of their diatom assemblages (Table 6). However, **site 4** had the lowest species richness value and the largest sedimentation index of all the sites, as it did in 2002 and 2003. The sedimentation index in 2004 suggests **severe impairment and nonsupport of aquatic life uses**. Caution should be exercised in using the sedimentation index as a diagnostic tool because many species in the motile genera *Navicula, Nitzschia*, and *Surirella* also tolerate other forms of pollution, including excess nutrients and heavy metals. Other metrics, including a few abnormal diatom cells, suggest minor to moderate impairment. The dominant diatom species at **site 4** were *Navicula cryptotenella* and *Nitzschia dissipata*. Both are motile, cosmopolitan species. A small increase in the pollution index here indicates that the stream had begun to recover from the influx of organic nutrients upstream.

A moderate change occurred between sites 4 and 5, which shared about 42% of their diatom assemblages (Table 6). As in 2002 and 2003, the diatom assemblage at **site 5** was similar to site 2 in that it was dominated by *Achnanthidium minutissimum*. The large percentage of this diatom species indicates **moderate disturbance**, perhaps from acid waters, metals toxicity, an increase in stream gradient, grazing by macroinvertebrates, or a combination of these factors. Diatom species richness and diversity remained low at **site 5** and approached the threshold for moderate impairment.

A significant amount of recovery occurred between sites 5 and 6 (Table 6), as it did in 2002 and 2003. Diatom metrics at **site 6** suggest good biological integrity and full support of aquatic life uses with only **minor impairment from sedimentation and heavy metals**. Normal values for the pollution index and the disturbance index indicate that the stream had recovered here from the influx of nutrients and metals upstream. *Cocconeis placentula*, one of the major species at **site 6**, is an alkaliphilous and eutraphentic diatom that attaches by its concave valve face to hard substrates (rocks). It is sensitive to excessive sedimentation, organic loading, and heavy metals. It is also adapted to the higher stream gradients recorded at **site 6** (Table 2).

Indian Creek. Both sites on Indian Creek had **good biological integrity**, as they did in 2002 and 2003. Diatom metrics indicate full support of aquatic life uses with only minor impairment from sedimentation (**site 8** only) and heavy metals (Table 6). The two sites shared 70% of their diatom associations. As in previous years, this indicates that Little Grizzly Creek had little or no effect on the diatom assemblage and environmental conditions at the downstream site. Without intervening tributaries or pollution sources, one may expect two adjacent reaches on the same stream to have at least 60% of their diatom associations in common (Bahls 1993). The dominant diatom species at both sites on Indian Creek was again *Staurosira construens*. This is a sensitive, alkaliphilous species that indicates low levels of organic matter, moderate levels of inorganic nutrients, high concentrations of dissolved oxygen, and **stable flows with low disturbance**. The relatively low stream gradients at sites 7 and 8 (Table 2) are conducive for the growth of free-living, non-motile species like *Staurosira construens* and *Staurosirella pinnata*.

Diagnostic Metrics and Trends (2002-2004)

In addition to the metrics presented in Table 6, some ecologically diagnostic diatom metrics were examined to determine the cause or causes of impairment observed at each station and to evaluate trends observed over the period of record (2002-2004). Three metrics—% circumneutral diatoms, % nitrogen heterotrophs, and % eutraphentic diatoms—were used to evaluate changes due to pH and loading by organic and inorganic nutrients, respectively. Two metrics—% abnormal diatom cells and the refined metals index (Table 4)—were plotted to examine the response of diatom assemblages to elevated concentrations of heavy metals.

pH. Diatom associations in Little Grizzly Creek and Indian Creek are populated primarily by circumneutral, alkaliphilous, and alkalibiontic species. **Circumneutral diatoms** (pH Group 3, Van Dam et al. 1994) occur mainly at pH values around 7. An increase in circumneutral diatoms indicates a probable decrease in pH. Alkaliphilous diatoms (pH Group 4, Van Dam et al. 1994) occur mainly at pH values >7. Alkalibiontic diatoms (pH Group 5, Van Dam et al. 1994) occur exclusively at pH values >7.

On average over the past three years, circumneutral diatoms accounted for about one-half or more of the diatom assemblages at **sites 2, 3, and 5** (Figure 2). These are the sites that are most likely affected by (acid?) mine drainage. Field pH measurements at the time of periphyton sampling do not indicate significantly lower pH values at these sites (Table 2). However, diatom assemblages may be better indicators of short- to mid-term pH values at the substrate level than instantaneous field measurements taken during daylight hours in the water column. Wide diurnal swings in pH are possible in productive systems such as this, and minimum pH values would most likely occur during the night when algae and bacteria are respiring and producing carbon dioxide. The pH values recorded during the day (Table 2), when algae are taking up carbon in photosynthesis, would approach maximum values.

Organic Nutrients. Nitrogen heterotrophs (Nitrogen Metabolism Groups 3 and 4, Van Dam et al. 1994) need elevated concentrations of organically bound nitrogen to prosper. As concentrations of **organic** nitrogen increase due to human disturbance, the percentage of nitrogen heterotrophs in the diatom association will also increase.

On average, nitrogen heterotrophs were most abundant at **site 3** (Figure 3), where *Nitzschia palea* was a major species all three years. This suggests that **site 3** received the largest loads of organic nitrogen, followed in order by **sites 2 and 4** (Figure 3). Growths of nitrogen-fixing cyanobacteria and associated true bacteria may be the source of these organic nutrients. Such growths are common in circumneutral, nitrogen-limited systems. Nitrogen-fixing cyanobacteria were common at the **4 upper sites** in 2004 and at all 6 sites on Little Grizzly Creek in 2002 and 2003. The ammonia and amino acids generated by nitrogen-fixing cyanobacteria and released upon their death and decay would be available as nutrient sources for bacteria and heterotrophic diatoms (Grant Mitman, Professor of Biology, Montana College of Mineral Science and Technology, personal communication). Sites 1, 5, and 6 on Little Grizzly Creek and both sites on Indian Creek supported much smaller populations of diatom nitrogen heterotrophs. **Sites 3 and 4** also supported large populations of nitrogen-fixing diatoms

(Rhopalodiales), confirming that inorganic nitrogen was limiting at these sites even though organic nitrogen was abundant and available to the diatoms.

Inorganic Nutrients. Eutraphentic and hypereutraphentic diatoms (Trophic State Groups 5 and 6, Van Dam et al. 1994) indicate elevated concentrations of **inorganic** nutrients that are important for diatom growth: nitrogen, phosphorus, carbon, and silica. As concentrations of these nutrients increase due to human disturbance, the percentage of eutraphentic and hypereutraphentic diatoms will also increase.

Conspicuous peaks of eutraphentic plus hypereutraphentic diatoms occurred at **sites 3 and 6** (Figure 4). These sites probably have the highest concentrations of inorganic nutrients. Conversely, **sites 4, 5, 7, and 8** appear to have the smallest concentrations of inorganic nutrients (Figure 4). **Sites 1 and 2** had intermediate levels of inorganic nutrients.

Heavy Metals. The percentage of abnormal cells (Figure 5) peaked at **sites 2, 3, and 4** in 2002, 2004, and 2003, respectively (Figure 6). Sites 5 and 6 had intermediate levels of abnormal cells and sites 1, 7, and 8 had the smallest numbers (Figure 6). The cumulative percentage of diatoms that are known to tolerate elevated concentrations of heavy metals peaked at **sites 2 and 3** during the three years of sampling (Figure 7). The remaining sites on Little Grizzly Creek supported intermediate percentages of metals tolerant diatoms, on average. The two sites on Indian Creek supported the smallest average percentages of metals tolerant diatoms (Figure 7).

Again, it should be noted that (1) metals-tolerant diatom taxa also tolerate elevated amounts of organic matter and (2) abnormal diatom cells may result from other toxic chemicals, such as ammonia. In the case of Little Grizzly Creek, these metrics likely indicate a combination of elevated metals and elevated organic matter. Toxic (un-ionized) ammonia is also a possibility.

Conclusions

1. From 2002-2004, aquatic life uses at sites 2 through 5 on Little Grizzly Creek were moderately to severely impaired and biological integrity ranged from fair to poor. The degree and specific cause of impairment and the site of maximum impairment varied from year to year.

2. The probable causes of impairment at these sites were (1) (acid?) mine drainage and associated heavy metals; (2) organic (mostly nitrogen) enrichment; and (3) excessive sedimentation.

3. A significant amount of recovery occurred between sites 5 and 6 on Little Grizzly Creek. Site 6 is relatively unimpaired and provides full support for aquatic life uses.

4. Site 1 on Little Grizzly Creek is relatively unimpaired and serves well as a control.

5. The periphyton community of Indian Creek shows little or no effect from pollutants discharged by Little Grizzly Creek. Diatom associations above and below the confluence of Little Grizzly Creek were virtually identical in all three years. Diatom metrics suggest full support of aquatic life uses and good biological integrity at both sites on Indian Creek in all three years of the study.

6. The largest impact to the system occurred in 2004 when the lowest algal genus richness and diversity were recorded in Little Grizzly Creek, when certain pollution-sensitive algal genera were absent from both streams, when there was a significant decrease in the number of non-diatom algal genera in Indian Creek from above to below the confluence with Little Grizzly Creek, and when the lowest diatom similarity index between sites 7 and 8 was recorded.

7. Nitrogen is the limiting nutrient in Little Grizzly Creek. Nitrogen-fixing diatoms and cyanobacteria are common. Growths of nitrogen-fixing cyanobacteria and associated bacterial slimes may be the source of the excess nitrogenous organic matter indicated at sites 2, 3, and 4.

8. Although field pH measurements at the time of periphyton sampling do not indicate acidity in Little Grizzly Creek, an increase in circumneutral diatoms indicates a decrease in pH at sites 2, 3, and 5. Diatom assemblages may be better indicators of short- to mid-term pH values at the substrate level than instantaneous field measurements taken during daylight hours in the water column. Diurnal changes in pH, including nighttime values, should be investigated.

9. Caution should be exercised in using the sedimentation index as a diagnostic tool because many species in the motile genera *Navicula, Nitzschia*, and *Surirella* also tend to be tolerant of other forms of pollution, including excess nutrients and heavy metals. By the same token, taxa that tolerate elevated heavy metals and used in the metals index also tolerate organic enrichment; and, abnormal diatoms that usually indicate the presence of heavy metals may also result from some other toxic chemical, such as ammonia, or from another environmental stressor.

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Table 1. Locations and sampling dates for periphyton collections from Little Grizzly Creek and Indian Creek in 2004.

Site No.	Waterbody Name	Station ID	UTM Coordinates	Sample Date
1	Little Grizzly Creek	PNFWALKER 1	0699130-4424389	9/9/2004
2	Little Grizzly Creek	PNFWALKER 2	0697614-4425160	9/9/2004
3	Little Grizzly Creek	PNFWALKER 3	0696718-4425710	9/10/2004
4	Little Grizzly Creek	PNFWALKER 4	0695528-4426924	9/10/2004
5	Little Grizzly Creek	PNFWALKER 5	0694859-4429242	9/13/2004
6	Little Grizzly Creek	PNFWALKER 6	0691770-4431715	9/13/2004
7	Indian Creek above Little Grizzly Creek	PNFWALKER 7	0691079-4434634	9/14/2004
8	Indian Creek below Little Grizzly Creek	PNFWALKER 8	0689830-4434876	9/14/2004

Table 2. Values for selected environmental variables measured or estimated at periphyton sampling sites on periphyton sampling dates in 2004. Source: The Buglab's Aquatic Macroinvertebrate Stream Health Assessment Information.

Variable	Unit	Station							
		1	2	3	4	5	6	7	8
Elevation	feet	5840	5700	5400	5040	4720	4250	3683	3670
Conductivity	micro Siemens	97.4	130.3	136.8	137.4	137.7	128.8	98.5	114.8
Field pH	standard units	7.99	8.18	8.53	8.38	8.31	8.12	7.79	7.51
Air Temperature	°C	20.6	NA[1]	17.0	29.0	15.0	28.0	26.0	17.0
Water Temperature	°C	9.4	12.6	14.1	14.0	13.7	14.0	18.0	14.0
Stream Gradient	%	1.5-2.0	4.0	3.8-4.0	4.5	3.0	4.0-4.5	1.5	1.5
Average Velocity	ft/sec	1.20	0.85	1.00	1.37	2.23	1.07	1.69	1.70
Overstream Shade	%	<24	NA[1]	19.5	NA[1]	NA[1]	58	0.0	6.0

[1]NA = not available

Table 3. Diatom association metrics used by the State of Montana to evaluate biological integrity in **mountain** streams: references, range of values, expected response to increasing impairment or natural stress, and criteria for rating levels of biological integrity. The lowest rating for any one metric is the rating for that site.

Biological Integrity/ Impairment or Stress/ Use Support	No. of Species Counted[1]	Diversity Index[2] (Shannon)	Pollution Index[3]	Siltation Index[4]	Disturbance Index[5]	% Dominant Species[6]	% Abnormal Cells[7]
Excellent/None Full Support	>29	>2.99	>2.50	<20.0	<25.0	<25.0	0
Good/Minor Full Support	20-29	2.00-2.99	2.01-2.50	20.0-39.9	25.0-49.9	25.0-49.9	>0.0, <3.0
Fair/Moderate Partial Support	19-10	1.00-1.99	1.50-2.00	40.0-59.9	50.0-74.9	50.0-74.9	3.0-9.9
Poor/Severe Nonsupport	<10	<1.00	<1.50	>59.9	>74.9	>74.9	>9.9
References	Bahls 1979 Bahls 1993	Bahls 1979	Bahls 1993	Bahls 1993	Barbour et al. 1999	Barbour et al. 1999	McFarland et al. 1997
Range of Values	0-100+	0.00-5.00+	1.00-3.00	0.0-90.0+	0.0-100.0	~5.0-100.0	0.0-30.0+
Expected Response	Decrease[8]	Decrease[8]	Decrease	Increase	Increase	Increase	Increase

[1]Based on a proportional count of 400 cells (800 valves)
[2]Base 2 [bits] (Weber 1973)
[3]Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species
[4]Sum of the percent abundances of all species in the genera *Navicula, Nitzschia* and *Surirella*
[5]Percent abundance of Achnanthidium minutissimum (synonym: *Achnanthes minutissima*)
[6]Percent abundance of the species with the largest number of cells in the proportional count
[7]Cells with an irregular outline or with abnormal ornamentation, or both
[8]Species richness and diversity may increase somewhat in mountain streams in response to slight to moderate increases in nutrients or sediment

Table 4. Proposed Metals Index (presumtive): % abundance of cells in the following species[1]:

Species	Synonyms
Adlafia minuscula	*Navicula minuscula*
Encyonema minutum	*Cymbella minuta*
Encyonema silesiacum	*Cymbella silesiaca*
Fragilaria capucina	
Fragilaria vaucheriae	*Fragilaria capucina var. vaucheriae*
Gomphonema parvulum	
Mayamaea atomus[2]	*Navicula atomus*[2]
Navicula arvensis	
Navicula minima[2]	*Eolimna minima*[2]
Navicula permitis	*Mayamaea atomus var. permitis*
Navicula seminulum[2]	*Sellaphora seminulum*[2]
Nitzschia palea	
Planothidium dubium	*Achnanthes lanceolata var. dubia*
Planothidium lanceolatum	*Achnanthes lanceolata*
Surirella angusta	
Surirella minuta	*Surirella ovata*
Synedra rumpens	*Fragilaria capucina var. rumpens*
Synedra ulna	*Fragilaria ulna*

[1]All of these species appear to tolerate elevated concentrations of heavy metals.

[2]These species, when present in large numbers, appear to confirm elevated concentrations of heavy metals.

Table 5. Relative abundance of cells and ordinal rank by biovolume of diatoms (Division Bacillariophyta) and genera of non-diatom algae in periphyton samples collected from Little Grizzly Creek and Indian Creek in 2004: d = dominant; a = abundant; f = frequent; c = common; o = occasional; r = rare.

Taxa	Station							
	1	2	3	4	5	6	7	8
Cyanophyta								
Calothrix		r/6						r/6
Hydrocoleum			o/4					
Nostoc	c/3	o/5		c/3			c/4	o/3
Oscillatoria	c/5	o/4	o/3				o/8	o/2
Schizothrix			c/2					
Tolypothrix	a/1	c/2	o/5	f/2				
Chlorophyta								
Ankistrodesmus							o/9	o/4
Bulbochaete							r/10	
Cladophora							o/6	
Closterium	r/7							r/5
Cosmarium		r/7					r/11	
Draparnaldia							c/5	
Mougeotia	o/6	o/3					a/2	
Oedogonium							o/7	
Spirogyra							a/1	
Stigeoclonium	o/4							
Bacillariophyta	f/2	a/1	a/1	a/1	c/1	o/1	a/3	o/1
No. of Non-Diatom Genera	6	6	4	2	0	0	10	5

Table 6. Percent abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from Little Grizzly Creek and Indian Creek in 2004. Underlined values indicate minor impairment; **bold values** indicate moderate impairment; **underlined and bold** values indicate severe impairment; all other values indicate no impairment and full support of aquatic life uses when compared to criteria for mountain streams in Table 3.

Species/Metric	PTC[2]	Station							
		1	2	3	4	5	6	7	8
Achnanthidium minutissimum	3	6.80	36.48	13.91	15.01	57.65	15.97	1.00	0.73
Caloneis bacillum	2	0.23		9.55	5.76	1.26	2.40	0.33	0.31
Cocconeis placentula	3	19.23	1.53	0.36			15.49	3.54	4.25
Epithemia sorex	3	0.47				0.11		7.86	6.32
Fragilaria atomus	3							5.54	5.18
Fragilaria capucina	2	11.96	0.12	0.24	0.23			0.22	0.41
Gomphonema kobayasii	3	2.34	0.71				19.09	0.22	1.87
Navicula cryptotenella	2	9.26	0.24	7.01	22.91	10.62	8.64	0.66	2.69
Navicula minima	1	0.82	8.85	8.10	2.93	0.34	0.24	0.44	1.24
Nitzschia dissipata	3	3.28	2.36	17.05	38.26	9.25	4.68	0.33	1.24
Nitzschia fonticola	3	9.61				1.60	2.52	1.55	2.49
Nitzschia palea	1	0.47	25.15	14.51	4.51		0.48	0.55	0.83
Pinnularia appendiculata	3		5.55						
Planothidium lanceolatum	2	0.94	1.77	0.85	0.68	12.79	11.52	0.22	0.41
Pseudostaurosira brevistriata	3							3.21	10.36
Rhopalodia gibba	2	1.52	1.77	9.31	2.37	0.57	0.36	1.33	0.62
Staurosira construens	3	0.47	2.13	1.45	0.23	0.23	0.48	43.19	24.66
Staurosirella pinnata	3	0.47	0.47					7.53	6.74
Number of Species Counted		56	33	29	20	22	34	54	63
Shannon Species Diversity		4.44	3.08	3.69	2.68	2.19	3.66	3.63	4.46
Pollution Index		2.57	2.17	2.14	2.49	2.70	2.66	2.77	2.70
Siltation Index		37.05	39.79	**55.38**	**73.36**	25.34	26.89	12.85	22.38
Disturbance Index		6.80	36.48	13.91	15.01	**57.65**	15.97	1.00	0.73
Percent Dominant Species		19.23	36.48	17.05	38.26	**57.65**	19.09	43.19	24.66
Percent Abnormal Cells		0.00	0.35	2.66	0.45	0.34	1.08	0.11	0.10
Similarity Index[3]			22.10	47.23	61.56	41.58	48.78		69.99

[1]A major species accounts for 5.0% or more of the cells at one or more stations in a sample set.

[2]Pollution Tolerance Class (Lange-Bertalot 1979): 1 = most tolerant; 2 = tolerant; 3 = sensitive to organic pollution

[3]Percent Community Similarity (Whittaker 1952) when compared to the diatom assemblage at the adjacent upstream station.